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STUDIES IN THE PHILOSOPHY OF SCIENCE

PART—I CAUSALITY

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The growth of the philosophy of science lay in the interpretation and generalizations of the classical mechanics, the atom and the corpuscular theory, the theory of relativity and the quantum theory. The development of the quantum theory led to newer concepts of atoms, the correspondence principle, wave mechanics and the Heisenberg's quantum mechanics. These ideas gave a new meaning to the terms causality, determinacy, chance and reality in science. Recently, however, scientists have begun to propose an alternate mechanism for the interpretation of the quantum theory which has necessitated a revision in our ideas in the philosophy of science. These studies deal with the impact of the development of scientific discoveries and thought during the last decade upon the philosophy of science in particular and philosophy in general.

The present paper discusses the concept of causality. In this paper an attempt has been made to show that the concept of causality in science is now likely to change once again to a universal principle inspite of the 'uncertainty principle' of Heisenberg generally accepted in the usual current interpretation of the quantum theory. In order to arrive at the correct perspective of the recently proposed alternate interpretation of the quantum theory it is necessary to examine briefly the nature of causality in science and how its meaning changed from time to time, getting limited in the usual current interpretation of the quantum theory, and again extended in the recently proposed alternate interpretation of the quantum theory.

The anthropomorphic character of causality suggests the view that all things in the world are mutually connected and that in the whole compass of the complexity of change and transformation there are relationships that remain effectively constant. The customary way to recognize the principle of causality in nature means that these relationships are necessary in the sense that they could not be otherwise.

In science the dynamic phenomena related to matter are studied and certain relationships are found between variables; and if these relationships are general they assume the title of a law. In order to arrive at a definitive picture of causality in science it is essential to examine first briefly the logical structure of scientific generalizations or laws.

Facts in themselves have little meaning. The meaning is provided by the relation between facts. Relation is something which is common to facts but does not belong to them, in the sense that it is not a part and parcel of them. Further, this relation is necessarily limited because it depends upon limitations of space and time and what may be termed as immediate experience. If it transcends both space and time, it becomes universal. The infinity of nature is manifested in the universals and universals are characterized by infinity. If physics deals with the relation between facts or particulars, philosophy or , to use the term given by Aristotle (1), metaphysics, transcends facts or goes beyond the limits of physics. It is essential to realise that a *particular* which may be in the form of a percept (Hume), a feeling (Bradley), a sense datum (Russel and Alexander), a sense content (Ayer) or an atomic fact (Ludwig Wittgenstein) can become determinate and intelligible only when a certain description of it is given. It is made intelligible through a process of self differentiation in a context of relations (2).

For the sake of argument the scientific laws may be considered causal or non-causal, that is, statistical in nature. It is difficult to make the distinction precise for practically and literally no scientific law contains the term 'cause' (3). "Since experience follows no prescribable pattern, an indispensable part of the task of attempting to reduce experience to understandability is to find how to describe or reproduce that experience as accurately as possible" (4). Further, "To understand a *concept*, you must know its operational definition. To understand a *definition* you must be familiar with the concepts in terms of which the definition is formulated" (5). Operational definition describes how the physical entity associated with the concept in question could be determined (or measured) instead of fixing its meaning in terms of other concepts. This type of operational analysis is useful, it is some times the only method available, it is necessary for science but it is not both a necessary and sufficient condition for the advancement of knowledge. In growing part of science the role of intuition and chance can not be minimised. Nevertheless the operational analysis has a great significance in science and is generally convenient to use. "In general we mean by any concept nothing more than a set of operations; the concept is synonymous with corresponding set of operations" (6).

As a working hypothesis we may take a causal law to mean one which can be so interpreted. In science a law may be said to be causal which can be expressed as a continuous function, the variables of which range over a set of quantities obtained by measuring specific qualities of individual entities and the calculated constants are interpretable as unique values of specific measurable qualities of individual entities. These laws are absolute in the sense that they hold anywhere in space and at any moment in time. It may be noted that the 'causal relation' lies in the deductive character of the explanatory system employed in the interpretation of 'causal' laws (7). In the non-causal law the form is of a discrete equation in which only certain discrete values of the variables in question have significance or meaning (8). The meaning may also be statistical—based on 'probability' and 'chance' (9).

The distinction between causal and non-causal laws of science is in part based upon the form of the equation and in part upon the deductive interpretation of the symbols (10). No equation alone is a law, it is the interpretation which makes it a law. The syntactic definition is to be supplemented by a semantic definition (11). The division of laws of science between causal and non-causal is dependent on the semantic definition. In the syntactic definition a scientific law whether causal or non-causal is a mathematical expression whose solution determines new values of the variables from given values if certain conditions are satisfied. In classical mechanics the semantic definition implies as statement from which descriptions as well as predictions of the exact data of future events can be derived, given certain conditions. It involves the principles of 'contact action', that is, propagatian of action from point to point. Given initial conditions and boundary conditions the deductive interpretation provides a statement giving a contiguity of point to point action and predicts future course of events limited by the boundary conditions only. Newton's idea that "We are to admit no more causes of natural thing than as are both true and sufficient to explain their appearance" (12) was widely acclaimed. Carnap (13) called the universal language of science as the 'protocol language'. Newton's idea of a central force being responsible for complicated motion providing a chain of causal action gave a sort of definitive interpretation to Kant's statement, "Alle veranderungen geschehen nach dem Gessetz der verknupfung von Ursache und Wirkung." Unlike Hume who stated, "We have no other notion of cause and effect; but that of certain objects, which have been always conjoined together ....we can not penetrate into the reason of conjunction", Kant believed that knowledge comes from a blending of sensuous presentations and understanding. The anthropomorphic limitations of understanding should serve as a guard against the blindness of unqualified percepts in any scheme of knowledge. In scientific laws the danger of using causality as a tautology must be avoided. We can use the cause-effect language in connection with a scientific law with a special interpretation only.

In quantum mechanics, for instance, the syntactic definition of the laws remains unaltered but the semantic definition must be changed to accord with the correct interpretation of the law which assumes the form of a statement from which descriptions as well as predictions of the probability distribution of future events can be derived, under certain given conditions. These laws are incapable of providing any picture of how a statistical law works. It seems that in order to have a correct perspective of causality in science the epistomological universal principle must be changed to the semantic conceptions as explained above.

Having briefly examined the laws of science it is now necessary to pass on to their logic. This would involve a further clarification in the meaning of the term 'causality'. A distinction will have to be made between causality as a word descriptive of the language of science or more particularly physics and causality as a term descriptive of the course of events in nature. Along with this it would involve a consideration of the extent of relation between the two (14).

It is said that Newtonian physics or classical mechanics is causal while quantum mechanics is not. Classical mechanics concerned itself primarily with the laws governing the motion of bodies through space. Newton's laws of motion deal with forces external or internal and are represented by differential equations and imply that the future behaviour of a body depends upon the values of position and momentum at any given time; it is predictable with the help of laws of forces provided we know the initial and boundary conditions of the problem. From this we got the philosophical abstraction that mathematical differential equations are the cause of physical forces existing in the universe and the whole universe is amenable to computation represented in Laplace's ideal of the so called *world formula*. Newton's laws were found to be universally obeyed. Their universal validity gave rise to mechanistic philosophy, where causal connection between events assumed the role of physical necessity and determinism in the course of events. Thus 'mechanism' and 'determinism' in their widest sense represent only a philosophical attitude towards the laws of classical mechanics. The laws themselves are 'causal' and 'deterministic' in a restricted sense only (15).

It may be pointed out here that the so called classical physics even in the hey day of the triumphs of mechanistic philosophy began to develop in directions which tended to depart from the general framework of the original form of this abstraction. The study of macroscopic properties of matter, particularly the advent of the laws of electromagnetic field, expansion of the kinetic theory of gases and the use of statistical explanation in the laws of thermodynamics weakened the view to some extent. There is little doubt that such studies provided a more detailed description of the 'process' and necessitated a revision of the original concept which still retained its deterministic character. For instance, in the field theory 'causal' relations are still transmitted from point to point—whatever occurs in a given time and place in the field is dependent only on the values of the field quantities in immediate past or proximity of the event. The extension of the kinetic theory and the concepts of the laws of thermodynamics introduced 'statistical' laws. They involved the concept of 'probability' and 'chance'. Large numbers or mass events are not and can not be studied by laws governing individual objects or events. We need statistical laws to deal with them. The 'probability' and 'chance' in these laws does not imply a break down of principle of causality. It can only mean the negation of causality if the term is taken to be identical with Newton's laws of motion and anything outside the realm of these laws must necessarily be alien to it. It is obviously absurd to restrict the meaning of causality to this narrow range. Probability in statistical laws of this type is a collective property of a large number of objects or events. It is a physical property of physical events and is manifested under specific observable conditions. Here 'chance' is not synonymous with 'no cause'. It has no meaning beyond 'probability' of the statistical laws. It is a relative not an absolute concept. This confusion is due to the limitations of the language (16). Science in these laws uses only a relative concept of 'chance' and 'probability'. Mathematics furnishes formal rules governing them. Statistical laws are also differential equations, more or less, of the same type as those used in classical mechanics and, under certain conditions, can predict as well as the laws of Newtonian motion. All that is needed to say is that causality in science is of two types—deterministic and statistical. Both the types retain the essential features of contiguity, point to point action and predictability. One is applicable to individual objects or events and the other to a number of objects or mass events.

In the beginning of the twentieth century a new philosophical abstraction was gradually introduced in the 'mechanistic philosophy'. This abstract view recognized the fundamental quality of 'probability' and 'chance'. The mechanistic view was extended in making the Newtonian laws as approximations to statistical laws. The position was similar to from 'many to one' and the deterministic character of 'one to many laws' was shaken. The individuality was sublimated in the general or mass phenomena. The germs of this indeterministic mechanistic point of view are thoroughly discussed by von Mises (17) and elaborated by others (18). This, however, does not mean that the world is really 'statistical' and is governed by laws where the macroscopic phenomena is reduced to microscopic phenomena. What it really means is that the so called microscopic phenomena—the behaviour of atoms generally occur *en masse* or our study is confined to *en masse* behaviour of these individual microscopic entities. A pertinent example in this connection is radioactive decay in which disintegration of atoms is expressed as a statistical law which means that a certain number will disintegrate in a given time and from that though we can compute the average life time of the atom, it tells nothing about when a particular atom would disintegrate (19). These theories and laws are really meant to convey that when further studies of physical laws are persued it becomes increasingly apparent that the so called 'fundamental' quantitative theories of classical mechanics are actually approximations to still deeper and more general theories containing new type of entities governed by new type of laws which may or may not be modifications of the known laws.

A marked shift in the mechanistic philosophy and a revolution in science was ushered in by the introduction of quantum theory. In the classical pre-quantum physics the common postulate behind all theories is that it is possible to represent the state of the physical universe by elements distributed in the frame work of three dimensional space and evolving in a continuous manner in the course of time. The mathematician Descartes who may be said to be the father of rationalism indulged in the 'cartesian dream' of all knowledge. Spinoza, however, asserted that knowledge is a reflection upon knowledge

(20)—a point of view developed by Leibnitz into innate ideas and petite perceptions (21). The world of science was recognized to be constituted of petite perceptions derived on the basis of 'Law of Sufficient Reason'. The petite nature of scientific perceptions was demonstrated by relativistic ideas which emphasized that neither space nor time has absolute character and the absolute character is preserved only by the four dimensional continuum called space-time (22). The theory of relativity though it revised our ideas relative to space and time profoundly yet it did not cause a breach in the classical determinism. The basically newer concept of quantum came from the microscopic domain where the relativistic concepts of space-time have not much signinficance.

The basic postulate of the quantum theory is that energy is regarded as existing in discrete amounts or quanta and a given amount of energy may be considered as an integral multiple of a fundamental unit. In quantum theory energy is supposed to have a certain atomicity in the form of light quanta or in the form of discrete allowed energy levels for matter. It appeared that both matter and energy seemed to have two possible aspects—that of a wave and of a particle (23). The basic laws governing these particles appeared to be statistical in form. In general, these laws only predicted the probability that a certain result could be obtained in the observation of the atomic system. A question was raised that underlying these statistical behaviour can there be a regular precisely defined motion of atomic particles such as an electron and with refinement of technique it may be possible to observe it. The problem was discussed by Heisenberg (24) who came to the conclusion that the limitations are dependent upon the agent such as light employed for observation. Any form of energy employed for observation being particulate in nature is sure to disturb the fundamental particles in the attempt of being observed. Ultimately a situation would be reached where it would not be possible to determine both the position and the momentum of the particle (say electron) simultaneously. The more accurately the momentum is determined, the less accurately the position can be defined and *vice-versa*. This limitation is superposed by nature and is inherent in the nature of things. Heisenberg went a step further and boldly asserted that this indeterminacy relationship which he deduced from quantum theory is a manifestation of a very fundamental all pervasive general principle and must be considered as a basic law of nature (25). The next logical step was to assume this law of nature as universal and assert that all other laws will have to be consistent with these relationships and the future course of events would show that the behaviour of atomic particles is even less precisely definable than is possible in terms of quantum theory (26).

It is clear that if the indeterminacy principle is assumed to be an absolute and final law it implies a break down of causality in connection with phenomena that depend significantly on the laws of atomic domain (27)

Von Neumann (28) extended the ideas and derived a theorem which states that it would not only be impossible to verify experimentally any causal theory that aimed to predict the behaviour of an individual system at the atomic level, but it is impossible even to conceive of such an explanation. The general rule is, "The larger the object under investigation and the smaller and finer the instrument, the lesser is the magnitude of error" (29). When, however, the size of the objects is of atomic dimensions "...........the measuring instruments can not be made finer than the objects to be surveyed" (30). Under these conditions, "If there is determinism at all, it is a determinism of one erroneous measurement by another erroneous measurement" (31).

The indeterminacy principle was, however, not limited to mean "......... an inadequacy of our measuring instruments" (32) but its sense was extended to be regarded as a reflection of the fact that no causal laws exist and the question of even 'metaphysical variables' can not arise. The concept of continuity must be given up in the atomic domain as the quantum transfers of energy are indivisible, the motion must necessarily be also quantized. This leads to what Bohr has termed the "irrational trait" (33) in the process of the transfer of a quantum from one system to another. This gave rise to the principle of complementarity (34) which briefly states that we can not have a precisely definable conceptual model of any type and that we are restricted to complementary pairs of inherently imprecisely defined concepts, such as position and momentum, wave and particle and so on. These are reciprocally related and experimental condition would be able to define only one of these reciprocally related entities. The protagonists of the quantum theory once again assumed that this conclusion is absolute and final. This forces us to conclude that the basic properties of matter can never be understood rationally and that complementary pairs of imprecisely defined concepts will be essential for detailed treatment of every domain that will ever be investigated. This leads to a completely indeterministic mechanism where the objective reality is denied in the microscopic domain and so the principle of causality is renounced— "..............every object and definable property in the world can be described in terms of nothing more than a set of purely quantitative laws of probability fitting into a certain general physical and mathematical scheme that is absolute and final" (35).

In the pre-quantum era the 'World' was deterministic and in the quantum era it has become probabilistic. It appears that scientists have a tendency to assume that the general features of the most fundamental theory that happens to be available at the time possess a final and an absolute character. Even though scientist philosophers enjoin upon the physicist that his attitude be "...........one of pure empiricism. He recognises no *a priori* principles which determine or limit the possibilities of new experience " (36) the vast majority of upholders of quantum mechanics forget that one can progress only "........by breaking drastically with the past" (37). Majority of the physicists insist upon the opinion "........That indeterminacy principle makes it imperative for us to recast the entire world of Classical Physics. Instead of causal laws based on inductive methods, we shall have certain mathematical formulae and concepts for transcribing the probabilities of an indeterminate universe" (38). The constant refrain of articles in the *International Encyclopedia of Unified Science* is that there is no knowledge beyond quanta and that for scientific knowledge certain norms are necessary. It is seldom realised that the view is self contradictory. It is not exhilerating to see the Positivists specifying the procedure of all knowledge in so dogmatic a manner.

The indeterminacy principle is based on three fundamental properties *viz.*, (*i*) the quantization of energy and momentum in all interactions, (*ii*) the existence of wave-like and particle-like aspects of these quanta and (*iii*) the unpredictable and uncontrollable character of certain features of individual quantum process. In all these fundamental properties there is a basic assumption that there cannot be a deeper level of causally determined motion beyond quanta. This is taken to be *a priori* knowledge though it is supposed to be deduced from *a posteriori* knowledge. In making quanta absolute a circular reasoning is followed in the maze of which certain essentials are completely forgotten.

Heisenberg holds the view that human brain, broadly speaking, is incapable of conceiving things beyond field (or waves) or particles (39). We can only conceive of what we see in every day experience. The conceptual domain is restricted to classical physics and finds its limit in reaching the quantum level. Any attempt to go beyond it is doomed to failure.

It is seldom realised that the very process by which we have reached the quantum level negatives the argument. Kant with the help of his 'Transcendental Aesthetic' and 'Transcendental Analytic' had shown long ago that there is a particular pattern of knowing facts. It is thought which gives communicability to particulars of sense data. We started from the laws of classical mechanics and by refinement of concepts and thought reached the quantum level. What is there to prevent us to go beyond quantum level ?

Such philosophical concepts as "Empiricism", "Positivism", "Operationism" have generally led to the adoption of the view that we should not postulate the existence of entities beyond the present methods of observation. Such a type of 'positivism', it may out right be stated, is as 'non-sensical' as atoms were 'non-sensical' to Mach because it was not possible to observe them as such. To assume that we have reached such *a priori* character in quantum mechanics that it can never be altered or modified is to assume that the universal character of knowledge is limited. This would result in a *cul de sac*. The crisis character of this is being increasingly realised by intelligent physicists all over the world.

Even the history and methodology of science is against any such sweeping assumptions. Science reveals a peculiar relationship between individual and statistical laws. The individual laws of classical mechanics could not be vindicated in the domain of classical mechanics. Further development found them to be insufficient or only an approximation of statistical laws. The laws of quantum mechanics are perfectly valid in the quantum domain but they have begun to show weakness*. Like any other theory, "In its present state of development the quantum theory is also not complete enough to treat all the precise details of the motion of the individual electron, light quanta etc. This would logically lead that to treat such details we would have to go to some as yet unknown deeper level—a sub-quantum mechanical level of continuous and causally determined motion, which would in its turn lead to the laws of quantum mechanics as approximations holding at the level of atomic particles". (40) Once a sub-quantum mechanical level is postulated the theorem of Neumann would be inadmissible.

The criticism given earlier is not to belittle the importance of the fundamentals of quantum theory but it is meant to impress the need for going beyond quanta to over come the crisis in scientific thought. Once it is realised that the domain of knowledge need not be confined to quanta, one will begin to search alternate interpretations of the quantum theory.

Even as early as 1926-27 when the quantum mechanics was getting firmly grounded there were mild suggestions to revaluate the quantum principle. L. de Broglie (41) and independently E. Madelung (42) almost at the same time proposed alternate interpretation of quantum theory. L. de Broglie in his paper published in *Journal de Physique* of May, 1927, put forward "The theory of double solutions". In his book, *The Revolution in Physics,* de Broglie has given an account of his views under the heading 'Will quantum physics remain indeterministic ?' (pp. 220 ff.) His theory of double solution implied the possibility of a sub-quantum level. He presented his ideas at the 5th Solvay Congress on Physics in October, 1927. He has recorded in his book that he was vehemently criticised by Einstein and even though the chairman (Lorentz) tried to support him, he was disheartened and practically gave up his ideas to fall in line with the work of Bohr, Heisenberg, Pauli and Dirac. Mention must also be made of the efforts of Blokhinzhev and Terletzky (43) who made a plea for regarding the current quantum theory as essentially statistical in nature and hoped that it would be replaced by a more detailed theory dealing with sub-quantum phenomena. Then came the articles of D. Bohm (44) in 1952. Bohm in his book *Causality and Chance in Modern Physics* records (pp. 110) that he worked out his ideas after discussion with Dr. Einstein in 1951. At that time he was ignorant of the earlier work of L. de Broglie. In these papers Bohm enlarged significant arguments in favour of what may be termed as the causal interpretation of the fundamentals of quantum theory. The argument was carried far enough to counteract the fundamental objections which were raised earlier against the suggestions of de Broglie. These papers seem to have stirred the old veteran de Broglie who once more took up his earlier neglected concepts and is trying to develop newer interpretation of quantum theory with help of Henri Poincare and M. Jean-Pierre Vigier (45). Vigier working with Bohm has developed a newer interpretation of the statistical significance of $/\psi/^2$ in wave mechanics (46). Bohm is consistently making efforts to remove artificial and unsatisfactory aspects of the theory (47) and has improved it considerably. The attempts for a causal interpretation of the quantum theory are not only confined to Bohm but others like Takabayasi (48), Fenyes (49) and Weizel (50) are also working in similar directions.

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* An interesting comparison of Brownian motion with quantum laws has been suggested by Bohm. See Appendix III

From the preceding paragraph it is clear that since 1950 or near about scientists have really begun to question the usual interpretation of the quantum theory. There gradually has appeared an appreciation of the need for modification. It cannot be said unequivocally at present, that the attempts to modify the usual interpretation of the quantum theory have been successful in formulating a new definitive theory but it can positively be now asserted that scientists are no longer completely satisfied with continuing on the basis of research within the framework of the usual interpretation. They are seeking newer interpretations and the best of efforts at present seem to lie in finding a causal interpretation of wave mechanics to rescue the quantum science from its present *cul de sac*.

A summary of newer interpretation as proposed by Bohm is given below (51) :—

(*i*) That connected with each 'fundamental' particle of physics such as an electron is a body existing in a small region of space. The probable size of this region is such that in most applications of the atomic level it may be approximated as a mathematical point.

(*ii*) That associated with this body there is a wave without which the body is never found. The wave is assumed to be an oscillation in a kind of field which is represented mathematically by the ψ field of Schrodinger. Thus Schrodinger wave function is given a definitive meaning of an objective real field.

(*iii*) That the ψ field and the body are interconnected in the sense that the ψ field exerts a new kind of 'quantum mechanical force' on the body. Further, this force first begins to manifest itself strongly in the atomic domain.

(*iv*) That the body may exert a reciprocal influence on the ψ field but that this reciprocal influence is small enough to be neglected in the current quantum mechanical domain but is likely to be significant in the sub-quantum mechanical domain.

(*v*) That the force is such as to produce a tendency to pull the body into regions where $/\psi/$ is greatest.

(*vi*) That this tendency (*v*) is resisted by the random motions undergone by the body.

The random motions postulated in (*vi*) could have many sources. It is suggested that they might come from the random fluctuations in the ψ field itself or from several other sources which might exist in the sub-quantum level. Once these fluctuations are assumed they will produce a tendency to wander in a more or less random way over the whole space available to it. This tendency would be opposed by the 'quantum force' which pulls the body into places where the intensity of the ψ field is greatest. As a consequence of this we would get a mean distribution in the sub-quantum level which would correspond to Born's probability distribution $P=|\psi|^2$. Thus Born's probability distribution may not be considered as an absolute and final unexplainable property but may be said to follow necessarily out of the random motions originating in a sub-quantum mechanical level. In a similar way Bohm has shown that this interpretation leads to the conclusions which are consistent with essential results of the quantum theory (44,46).

Prof. Bohm himself points to certain objections to his theory which may be raised on technical grounds. These objections are :—

(a) The theory does not take into account the problems raised by the electron spin and the theory of relativity. Like Schrodinger equation it would not be adequate either in the domain of very high energies or very low energies.

(b) In the domain of very low energies when the theory is extended to more than one electron serious difficulties would arise because both Schrodinger equation and Dirac's equation describe the wave in the abstract 3N dimensional space when N number of particles are present.

(c) The suggestion in the theory in which wave and particle are regarded as different entities which interact in a way that is not essential to their modes of being, does not seem very plausible.

Criticisms of this type, Prof. Bohm has pointed out, are not directed at the logical consistency of the model proposed by him but are directed towards the inability of the model to explain certain essential characteristics of the quantum domain. He is now trying to extend and generalize the theory and is making an attempt to modify it in such a way as to meet these objections. Some of the directions in which he is progressing may be summed up, as follows :—

(*i*) That the electron is not a mathematical point and if it is considered to be sufficiently rigid the electron spin can then be interpreted in terms of the rotation of this body which gives rise to 'intrinsic' angular momentum, over and above that which is due to its orbital motion. On this basis a consistent interpretation of Pauli's equation is possible (47). It is further being tried to extend this theory to Dirac's equation to take relativity into account. The basis of this step, as Prof. Bohm tells us, is to suppose that ψ field can oscillate in several different ways so as to satisfy different conditions as obtained at the quantum level.

(*ii*) Further, Bohm has suggested the introduction of field in multidimensional space. There are alternate suggestions also made by de Broglie and Vigier (23).

In Bohm's theory the starting point is to suppose that basic entities are fields. These fields are then regarded as mechanical systems subject to quantum laws in such a way that the laws imply a number of important properties of the field. For instance it may be supposed that the fields undergo violent and very rapid random fluctuations, which are not directly observable at macroscopic (quantum) level because they average out to produce a negligible effect at this level. Over these random fluctuations may be superposed comparatively small systematic oscillations which at macroscopic level do not cancel out but add up to produce cumulative effects that are detectable. Certain properties of this field will be discrete and the discreteness may be responsible for particle like properties of the field.

With the type of assumptions indicated above Prof. Bohm is attempting to have a conceptual model in the sub-quantum mechancial level which may be defined in such a way or whose characteristic parameters may be supposed to be arranged in a manner that would lead to the laws of current quantum theory in a natural way as approximations holding at the quantum level.

One of the most interesting features of the theory is that one would have to go beyond quantum level to find any possible evidence of the sub-quantum level. Prof. Bohm suggests that such a level can be reached when we go to distances smaller than the Compton wave length of the electron ($3\text{x}10^{-11}$ cm.) and particles possess very high energy (100 mev or more). He talks of distances of the order of 10^{-13} cm. which are of nuclear dimensions. In desperation, so to say, consistent with his indeterminacy principle Heisenberg has proposed that for distances shorter than a 'fundamental length' (of the order 10^{-13} cm.) even the properties of space and time would cease to be definable. Prof. Bohm's contention is that it is only in this region of small distances and high energies it would be possible to see some manifestation of the sub-quantum level.

Now in the field of small distances and high energy of particles a very confusing phenomena has already been observed. Protons and neutrons can transform into each other. Positrons, neutrinos and a host of mesons and several new particles called hyperons have been discovered (52). These so called new particles are generally unstable and transform into each other and ultimately 'decay' into neutrons, electrons and protons(53). They originate in high energetic collisions of other particles with nuclei. It is significant to note that under these conditions the distances are smaller than the Compton wavelength of the electron and particles carry energies of the order of 100 mev or more. It is tempting to suppose that the 'creation' of these newer meta-stable particles is a sub-quantum phenomenon. At present their significance is not clearly understood on the basis of current quantum theory. It appears plausible to suppose that postulation of a sub-quantum level of the type suggested by Bohm which it might be stated can not be said to have reached any sound definitive level at present, might be fruitful in providing the requisite explanation of the bewildering phenomena referred to above.

Whether the ideas of Prof. Bohm would withstand the test of time only future can tell. But the idea even in its present incomplete state is metaphysically more unifying and satisfactory. The postulate of a sort of mechanical concept beyond the quantum level serves to stabilise 'causality' in its shaking foundations in science. The conception that the mechanical explanation can go further in the quantum domain opens up immense possibilities for the future. The quantum domain becomes explicable on the basic of these newer concepts and the laws of quantum mechanics acquire a new meaning. The limits imposed by indeterminacy are over come and one begins to see a sequence in the logic of development of science.

Science started with a mechanistic philosophy abstracted initially from the work of Newton and proceeded to the field concept which is essentially a concept of quantitative changes that lead to qualitative changes where chance and statistical laws find a place ; to quantum theory which asserted that the state of a system is subject, in general, only to a statistical determination and reached finally to the present theory that postulates sub-quantum entities and asserts that the indeterministic of character of the quantum level is merely a natural inevitable sequence of the activities of entities in the sub-quantum domain. If the present theory concerning sub-quantum levels is correct it would demonstrate that the mechanistic assumption of the absolute and the final character of the theories is erroneous and each feature has only a relative and limited validity. This view in a sense goes beyond mechanism and transcends it. It emphasizes the qualitative infinity of nature and makes one realise the folly latent in all wisdom.

Philosophers have been telling us in several different ways that all human knowledge is of a fragmentary character and could not be otherwise. The theory proposed by D. Bohm amply demonstrates it in the realm of science. Science which gave birth to the 'mechanistic' view is once more being prepared to change it drastically. This newer theory gives a deeper meaning to the infinity of nature and suggests that 'chance' and necessary causal interconnections are the two sides of every real natural process. The present situation is surprisingly in support of Berkeley's philosophy. His philosophy of ideas reduced all reality to knowledge and all knowledge to percepts, which he believed cohered under a scheme of divinely ordained sequence. Whether the sequence is divinely ordained or not would forever remain uncertain but it is becoming increasingly abundantly clear that the theories of matter in science are evolving in a sequential manner and are providing deeper and deeper meaning to reality.

SUMMARY

Views regarding the nature of causality in science are discussed. The role of causality in scientific laws and relations from time to time have been elaborated. An attempt has been made to show that the concept of causality in science is now likely to change once again to a sort of universal principle inspite of the tenets of the usual current interpretations of the quantum theory. The recently proposed alternate interpretations of the quantum theory are cited in support of the causality principle emphasizing the qualitative infinity of nature.

Appendix I

The law governing radioactive decay is

$$N = No\ e^{-\lambda t}$$

where N represents the number of disintegrating atoms, that is, No is the initial number of the nuclei and N is the undisintegrated residue after t seconds, λ is a constant and e is the base of the natural logarithm which is 2.718.

If $t = T$ seconds, a time in which half of the originally present nuclei have disintegrated, then it can be shown that T is related to λ.

From the law of radioactive decay—

$$\ln\ (No/N) = \lambda .\ t$$

when $t = T$, $N = No/2$ and hence

$$\ln \frac{(\ No\ )}{(No/2)} = \lambda .\ T$$

$$i.e.\ \ln\ (2) = \lambda .\ T = 0.693$$

$$\text{hence, } T = 0.693/\lambda$$

T is called the 'half life' of the atoms under consideration.

The point is that the equation of the radioactive decay tells us that the members disintegrating at any time depend upon the total number present. We can even evaluate the 'half life' of atoms under consideration. The law, however, tells us nothing about individual atoms.

Appendix II

Einstein gave the quantum relation—

$$E = h.\ \nu$$

where E is the energy, h is a constant known as Planck's constant whose value is 6.62×10^{-27} erg-secs, ν is the frequency. This means that in the particle like manifestation of quanta the numerical value E of the energy of the particle is always related to the frequency ν in the wave like manifestation.

de Broglie gave the relation—

$$p = h/\lambda$$

where p is the momentum and λ the wavelength. This means that the numerical value p of the momentum in the particle like manifestation is in a like manner related to λ, the wavelength, in the wave like manifestation.

The indeterminacy relationship as suggested by Heisenberg can be put as

$$\Delta p. \quad \Delta x = h$$

which means that the change in momentum p represented by Δp is reciprocally related to change in position x represented by Δx and this reciprocal relationship finds a limit defined by the Planck's constant h. The reciprocal relationship between position and momentum has an ultimate limitation.

Appendix III

The botanist Brown observed that tiny spores of plants were performing a random motion in the field of his microscope. This is called the Brownian motion and is performed by particles of size 10^{-4} cm. or less. Before the cause of the Brownian motion was known that could be studied as an aggregate or obeying statistical laws. These laws would have been indeterministic as the laws of quantum mechanics. Further, it has shown that if we observe a moving smoke particle through some short interval of time Δt, we will find random fluctuations of the magnitude Δx in the mean position, and of magnitude Δp, in its mean momentum which satisfy the relationship—

$$\Delta p. \quad \Delta x = C.$$

where C is a constant.

This relation is similar to Heisenberg indeterminacy relationship (Appendix II) except that Planck's constant h has been replaced by another constant C which depends upon the state (temperature, viscosity etc.) of the gas.

We now know that the Brownian motion is the manifestation of the molecular movement and the cause of the motion of the particles is the impact of the neighbouring molecules.

The point is that the explanation of the Brownian movement could have been only statistical and indeterministic if our knowledge had not proceeded beyond the level of the Brownian movement. To find the cause of the Brownian movement one has to go beyond the level of Brownian movement. The factors determining the irregular Brownian motion can be found only if one goes to sub-Brownian motion level(in this case atomic or molecular level). In a similar way it can be supposed that in the present state of development of the quantum theory the explanation of the phenomena at the quantum level can only be statistical and indeterministic. To find rational causes for the phenomena observed at quantum level one has to go beyond quantum level and postulate a sub-quantum mechanical level of continuous and causally determined motion. The statistical laws governing Brownian motion can be explained on the basis of molecular motion likewise the statistical indeterministic laws governing quantum phenomena should be explicable by the motion of entities present in a sub-quantum level.

REFERENCES

1. See Collingwood, R.G., *An Essay on Metaphysics*, pp. 6
2. Roy, S.S. 1952-53, Philosophy and Physics, *Saugar University Journal*, Vol. I(**2**), pp 85-103.
3. Kattsoff,L.O. 1957, Causal and non-causal laws., *Physical Science and Physical Reality*, Chap. VIII, pp 103-115
4. Bridgman, P.W. 1955, Operational Analysis, *Reflections of a Physicist*, Chap I, pp 7
5. Kolin, A. 1950, Foreward, *Physics its Laws, Ideas and Method*, pp. 15.
6. Bridgman, P. 1926, *The Logic of Modern Physics*, pp. 5
7. Ushenko, A.P.,1942,The Problem of Causal Inference, *Philosophy of Science*, **9**, pp.132ff.
8. Planck M. 1953, Concept of Causality in Physics, *Readings in Philosophy of Science*, (P. Wiener Ed.), pp. 77-87
9. Fiegel, H. 1953, Notes on Causality, *Ibid.*, pp. 408-418
10. Schlick M. 1932, Causality in Everyday Life and in Recent Science, *University of California Publications in Philosophy*, Vol. **15**.
11. Arthur, P. 1949, The Analysis of Causality, *Elements of Analytic Philosophy*, Chap. IV pp. 202-223.
12. Newton, 'Rules of reasoning in Philosophy', *Principia* (Cajori Ed.), Book III.
13. Werkmeister, W. H. *A History of Philosophical Ideas in America*. pp. 571
14. See Born, M. 1949, *Natural Philosophy of Cause and Chance* and compare Silberstein, L. 1933, *Causality*.
15. Hutten, E.H. 1956, The Concepts of Classical Physics, *The Language of Modern Physics*, Chap. III, pp. 73 ff.
16. An interesting article is Cassirer, E. 1942, The influences of language upon the development of scientific thought, *Journal of Philosophy* **XXXIX**, pp. 309 ff.
17. von Mises, R. 1951, Statistik und Wahrheit, *Wahrscheinlichkeit*, dritte Auf. wien, (Springer)
18. See Weyl, H. 1916, *Ann der Mathematik*, **77**, pp. 333
    Steinhouse, H. 1953, *Studia Mathematika*, **13**, pp. 1
    Klein, G. *et al*, 1953, *Physica*, **19**, pp. 74, 89, 1053
    Bohm, D. and Schutzer, W. 1955, *Supplemento al Nuovo Cimento*, Vol. **II**, Series X, n.4,pp.1004
19. For mathematical note see Appendix I
20. *Tractus de Intellectus Emendctione*, j XIV
21. Leibnitz, *Monadology* (Latta's E.T), pp. 360 ff.
22. Einstein, A. 1956, *The Meaning of Relativity* (revised ed.)
23. de Broglie, L. 1954, *The Revolution in Physics*, Chap. 8
24. Heisenberg W., 1930, *The Physical Principles of the Quantum Theory*, see introductory chapter.
25. For mathematical note see Appendix II.
26. Several excellent reviews are available. A few notable ones are :—
    Darwin, C.G. 1932, *New Conceptions of Matter*
    Einstein, *A et al*,1935, Can Quantum Mechanical Description of Physical Reality Be Considered Complete, *Physical Review*, Series 2, Vol. **47**, pp 777. ff.
    Infeld, L. 1934, *The World in Modern Science*
    de Broglie, L. 1939, *Matter and Light.*
    Bergman, G. 1947, The Logic of Quanta, *Am. Jour. of Physics*, Vol. **15**, 397-408,

497-508.
Menzel *et al*, 1949, Physical Principles of Quantum Theory, *Philosophy of Science*, **16**, no 4, pp. 303 ff.

27. Some important critical reviews are :—
    Reichenbach, H. 1946, *Philosophic Foundations of Quantum Mechanics*
    Born, M. 1949, *Natural Philosophy of Cause and Change*, Chap. VIII, IX.
    Born, M. 1953, The Interpretation of Quantum Mechanics, *Philosophy of Science* **IV**, No. 14, pp. 95 ff.
    Whyte, L.L. 1956, Fundamental Physical Theory, *Philosophy of Science* (British), **1**, pp. 303 *et seq.*
28. von Neumann, J. 1932, *Mathematische Grundlagen der Quantenmechanik*
29. Jordan, P. *Twentieth Century Physics*, pp. 121
30. Jordan, P. *Ibid.*, pp. 129.
31. Jeans, J. *Physics and Philosophy*, pp. 178.
32. Eddington, *The Philosophy of Physical Science*, pp. 90.
33. See Bohr, N. *Atomic Theory and Description of Nature* and also(34).
34. Schlip P.A. Ed., 1949, *Albert Einstein, Philosopher Scientist* for fuller description.
35. Bohm, D 1957, *Causality and Chance in Modern Physics*, pp. 103.
36. Bridgman, P.W. *Logic of Modern Physics*, pp. 3.
37. Bridgman P.W 1955, *Reflections of a Physicist*, pp. 462.
38. Jordan, P. *Twentieth Century Physics*, pp. 126-127.
39. Heisenberg, W. 1930, *The Physical Principles of Quantum Theory*, pp. 5.
    See also Weizacker C.F. 1952, *The World View of Physics*, pp. 104.
40. Bohm, D. 1957, *Causality and Chance in Modern Physics*, pp. 80
41. 1926, *Compt Rend.*, **183**, pp. 447.
    1927, *Ibid.*, **185**, pp. 380.
42. 1926, *Zeit. f. Phys.* **40**, pp. 332.
43. 1951, *Uspekhi. fizic. Nauk*, **45** ; French translation in 'Questions Scientifiques', Vol. I, (1952).
    See also Blokhinzhev, D.J. 1953, *Grundlagen der Quantenmechanik*
44. 1952, *Phys. Rev.*, **85** pp. 166 and pp. 180.
45. See de Broglie, L 1953, *La Physique Quantique Restera-tella Indeterministe*
46. Bohm, D, and Vigier, J.P. 1954, *Phys. Rev.*, **96** pp. 208.
47. See Bohm, D. 1953, *Prog. Theor. Physics*, **9**, pp. 273.
    Bohm, D. Schiller, R. and Tiomono, J. 1953, *Supplemento al Nuovo Cimento*, **I**, Series X, pp. 48.
48. 1952, *Prog. Theor. Physics.*, **8**, 143 ; **9**, 187
49. 1952, *Zeit. f. Physik.*, **132**, pp. 81
50. 1953 ; *Ibid.*, **134**, pp. 264 ; **135**, pp. 270.
51. Bohm D. 1957, *Causality and Chance in Modern Physics*, Chap. IV pp. 104-128
52. de Broglie, L. 1954, *The Revolution in Physics*, foot note on pp. 236
53. Marshak, R. E. 1952 (Jan.), *Scientific American*, pp. 22-27

STUDIES IN THE PHILOSOPHY OF SCIENCE

PART—II REALITY

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In part—I of these studies (1) an attempt was made to show that the concept of causality in science is now likely to change once again to a sort of universal principle emphasizing the qualitative infinity of nature. In this paper the concept of reality in science in the light of recent alternate interpretations of quantum theory is discussed. An attempt has been made to generalise the basic concepts of physical science about matter to lead to the conclusion that there exists an absolute, unique, objective *Reality* which can only be observed in parts and which for ever would remain unknown in its totality. In as much as no knowledge is completely free of errors, science by studying the relative in its inexhaustible multiplicity and diversity can lead only to a glimpse of this *Reality*, a glimpse which, however, can now be called a penetrating insight.

In writing this paper the author is conscious of the fact that "………the scientist who follows scientific thought as far as it will take him, is liable at any moment to become more than a scientist", (2) but is impelled by what Dewey calls the zeal for "enjoying the doubtful". The position may well be explained by remarks about how a practicing scientist may appear to an outsider "…………as a type of unscrupulous opportunist: he appears as a *realist* in so far as he seeks to describe the world independent of the act of perception; as *idealist* in so far as he looks upon the concepts and theories as the free inventions of the human spirit (not logically derivable from that which is empirically given) ; as *positivist* insofar as he considers his concepts and theories justified only to the extent to which they furnish a logical representation of relations among sense experiences. He may even appear as *Platonist* or *Pyhtagorian* insofar as he considers the view point of logical simplicity as an indispensable and effective tool of his research" (3).

The postulation of a sub-quantum mechanical level in the alternate interpretation of the quantum theory (1) by Bohm (4) and others (5) has opened up new vistas in the reality of *nature*. It has also disturbed many. In the symposium (6) held in the University of Bristol in April, 1957, L. Rosenfeld attacked Bohm's position in a paper with the title 'Misunderstandings about the Foundations of Quantum Theory'. In the same symposium P.K. Feyrabend read a paper entitled "On the Quantum Theory of Measurements" which examines the inadequacies of the usual interpretation as represented by the ideas of Bohr, Heisenberg and von Numann. The controversy still rages, as for example, in the year 1958 Rosenfeld reviewed Bohm's book '*Causa-*

lity and Chance in Modern Physics' in Nature with a revivalist fervour and used very strong language for those who dare to differ from Niels Bohr. There is a sadness as well as optimism well represented by the hymn in Rigveda addressed to Dawn (Uṣas)—"Obeying the behests of the gods, but wasting away the lives of mortals, Uṣas has shown forth—the last of many former dawns and the first of those that are yet to come" (7).

"Each age has its faith and our age is committed to science " (8). In our age"............you can not fail to see that scientific thought is not an accompaniment or condition of human progress, but human progress itself" (9). According to Whitehead philosophy is the critique of abstractions and so it cannot remain untainted from the abstractions derived from physical sciences from time to time. It is in the "small scale phenomena of physics that the ultimate nature of things lie hidden." (10) Till recently this domain appeared to have reached a final limit in quanta. We were doomed "......to sterility after a very limted period of progress" (11) but the postulation of an essentially mechanical sub-quantum level has ".........burst through the current abstractions" and has opened the gates to further progress. This event is bound to have repercussions on philosophy as philosophy without science is incomplete and science without philosophy is meaningless.

"The intellectual apprehension of the details of existence is called vijñāna as distinct from jñāna, or the integral knowledge of the common foundations of all existence. The two are only different sides of one pursuit." is enjoined in Bhagavadgita (12). One has to realise that ".........science has not legislated to the Universe" and ".........instead of prescribing of things what they must be, it has been the object of scientific method to discover what things are" (13). Science has the merit to ".........dispel the darkness oppressing the mind, shows up the incompleteness of its own world, and prepares the mind to something beyond it" (14).

Reality is a term which it is very difficult to define. Perhaps only that which can not be defined is *Real.* Nobody seems to have catalogued the various senses in which the term has been used by different thinkers or even by the same thinker. W. K. Clifford has noted that the term 'cause' has sixty-four meanings in Plato and forty-eight in Aristotle (15), but nobody to the best of my knowledge had in a similar way tried to catalogue the meanings of reality. Just as in part—I of these studies a start was made with a restricted meaning of the term 'causality' and then the meaning was extended to an all embracing principle, in a similar way the concept of reality is treated in this paper.

Reality may be said to be a unity or a unified system which is the universe. By universe is generally meant physical universe which is analysable in terms of sense data or "pointer readings"(16). How it is related to *Reality* in the sense "all that there is" or "all that one need to know" is a question which would not be considered for the present. In this sense reality would refer to *prakrti*. "The nature of prakrti is deduced from the nature of common things of experience by the aid of reason alone" (17). In consideration of the nature of prakrti it is best to have a realistic approach.

In the Nyaya-Vaiśeṣika school of Indian philosophy—"Existence is the most general characteristic of things, and it is on account of this that things are testified by experience to be existing" (18). In relation to *prakrti* the "………cardinal doctrine with all existentialists that existence preceds essence" (19) may be accepted. Further, with the realist one may say "whatever is, is real" (20) and "………things can be known as they really are" (21). The method of knowing this reality is the discipline called science whose content may be summarised as *concepts* or *constructs*, relation between *concepts* and the *grammar* for expressing this relationship.

One may start with the assumption that "………Everything that can be said about the universe must be said about an actual entity or a group or a nexus of actual entities" (22). Whitehead's method—The Method of Extensive Abstractions—"………the prolegomena to every future philosophy of nature "(23), can then be applied to study the relations of extensions between the 'events'.

Now the most important characteristic of matter in any form living or non-living is what has variously been described as change, motion, movement, transformation, flux and so on. Earliest record of this is found in Rigveda. The word Ṛta (24) literally means the course of things and hence implies the notion of change. But it is in the Upaniṣads "………the sparks of philosophic light appearing in the Rigveda shine out brighter and brighter" (25). In Chāndoga Upaniṣad "……… the material cause, *e.g.*, the clay, is spoken of as the only reality in all its transformations as the pot, the jug or the plate" (26). In a somewhat similar manner Herakleitos also noticed this property of change or flux (27). He gives the example of fire as burning, consuming and transforming things. Both in the Upaniṣads and in the philosophy of Herakleitos the idea of *many* to *one* and vice-versa or change was arrived at in all probability by observing the change in material objects such as clay into jug, pot, plate etc. and the change effected by fire.

Buddha concentrated not only on material objects but extended his observations to living beings. He was impressed by the transitoriness of all things, material or living and the manifold forms in which they appear. It is in the philosophy of Buddha that germs of many future schools of thought concerning this aspect of reality can be found. Accordingly, certain quotations from the philosophy of Buddhism are given below to illustrate this point.

"Things change. There is no being in the world, but only becoming. In such a state the supreme reality is the law of change, and that is causality" (28).

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"Causality is always self-changing or becoming" (29).

"Nature is one continuous vibration, an infinite growth bound by an iron chain of causality. It is continuous, whole, one and indivisible" (30).

"There is a cohesion of the past with the present which is broken up into a succession of before and after in our external treatment of nature"(31).

"Life is nothing but a series of manifestations of becomings and extinctions. It is a stream of becoming" (32).

"Change is the stuff of reality.........Each single phenomenon is but a link in the chain, a transitory phase of evolution, and the several chains constitute the one whole........." (33).

"It is a becoming without beginning or end. There is no static moment when the becoming attains to beinghood. No sooner than we conceive it by the atributes of name and form then it has changed to something else" (34).

"The causal evolution is not to be viewed as a mechanical succession of movements, in which case the world process becomes a series of extensions and fresh creations, but is one state working itself upto another state or informing it with a ceaseless pulsation"(35).

Buddha accepts that things are the products of conditions. "......'Everything is'—this is one extreme, O Kaccāna, 'Everything is not'—is another extreme. The truth is the middle........." (36). In this world of life and motion which is always changing, always becoming, the truth—the objective reality— is in the middle.

The germs of Buddhistic philosophy were in one form or another elaborated in our country in the so called epic age and later. Thus we find in Mahābhārata Vidur saying—"They have come from the unseen and would disappear into an unseen" (37), and in Bhagavadgīta, "Beginnings and ends are unknown, we only know the middle which is in constant flux" (38). Further, "None can for a moment stay without change for Nature arranges circumstances so that all must change"(39). "Evolution in Sāmkhya means the development of the categories of existence............evolutionary process is regarded as a differentiation of new stages as integrated in previous stages (samsṛṣṭa-viveka)" (40). The process of this type of evolution consists "......in the development of the differentiated (vaiṣamaya) within the undifferentiated (sāṃyavastha), of the determinate (viśeṣa) within the indeterminate (aviśeṣa), of the coherent (yutasiddha) within the incoherent (ayutsiddha). The order of succession is neither from parts to whole nor from whole to the parts, but ever from a relatively less differentiated, less determinate, less coherent whole to a relatively more differentiated, more determinate, more coherent whole" (41).

Upaniṣads derived their views by observation on material objects and Buddha developed his philosophy by observing both material and living objects. While the Upaniṣads say that things have no self-existence as such, but are products of a causal series which has no beginning or end, Buddha says things are the products of conditions" (42). In Buddhistic philosophy one can clearly see the germs of European Evolutionism which is essentially based on observations on material objects and living beings coupled with the scientific theory of biological evolution. The European advocates of Evolutionism in a scientific sense go a step further than Buddha.

Herbert Spencer initiated evolutionism in Europe. In his own words "………Evolution is an integration of matter and concomitant dissipation of motion during which the matter passes from a relatively indefinite, incoherent homogeneity to relatively definite, coherent homogeneity, and during which the retained motion undergoes a parallel transformation" (43). Bergson showed that whether we take life in general or life in individual consciousness the essential characteristic of a continuous flux is always to be found. He goes a step further and says that the motive force behind this evolution is élan vital. "Reality is………a creative implusion of endless duration………It is intuition which enables us to grasp the nature of that constant change, that Duration……which is………the stuff of reality" (44). Morgan carried the analysis a little bit further and in place of élan vital of Bergson considered that the guides of evolution are two principles——the resultant principle and the emergent principle (45). The emergent principle is equivalent in a sense to "chance" like situation in the continuity of evolution. All philosopher advocates of evolutionism recognize the fundamental importance of continuous flux, change or motion. From observation in limited sphere they have tried to arrive at a general principle governing all things. This general principle must, however, be accepted with caution. "What is the status of enduring stability of the order of nature ? There is the summary answer, which refers to some greater reality standing behind it. This reality occurs in the history of thought under many names, The Absolute, Brahman, the Order of Heaven, God. My point is that any summary conclusion jumping from our conviction that there is an ultimate reality which, in some unexplained way, is to be appealed to for the removal of perplexity, constitutes the great refusal of rationality to assert its rights. We have to search whether nature does not in its very being show itself as self explanatory" (46). This leads to a little detailed consideration of the nature of *prakrti*. This was done in science in proceeding beyond the matter visible to the eye.

Proceeding beyond the human eye science gradually discovered molecules, atoms, atomic particles, quanta. Each of these discoveries in turn were considered to be fundamental and matter was in a sense reduced to these entities whose essential characteristic is discreteness. Thus gross matter was reduced to discrete entities and this idea found an ultimate limit in quanta. The wave and particle character of the so called fundamental entities of matter were merged as a sort of duality in one—a duality characterized in an ultimate limit set by Heisenberg's uncertainty principle. One can suspect that these ideas acted as background in the mind of many thinkers during the period of their discovery and their gradual firmer foundations in science. Discreteness disturbed idealist theories and the wave-particle duality in one urged the thinkers to explain the polymorphic character of nature in some new way which would not effect the principle of a sort of ultimate discreteness.

The advocates of realism believed that the external world is direct and immediate and is not an inference from sense data. According to Broad, "........It is false logically to suppose that the *existence* of a physical world in general could be inferred from the existence of our sensa........I suppose that the existence of senssa is a necessary condition but it is not a sufficient condition of my belief in the existence of physical world" (47). Russell called realism as "Logical Atomism"—whatever is, is real. The so called critical realists considered the world as 'logical construction' out of facts of our sense data. Each entity is considered true or real "in its own right" (48). Realists recognize that things as they really are, are a diversity and develop a sort of pluralistic metaphysics. To them space-time is real and reality is a process. This process is similar to the philosophies of change, flux, motion but with a difference and the difference is that it is not considered to be without a future. "The world as it passes perishes, and in perishing it yet remains an element in the future beyond itself" ; hence as we perish we are immortal (49). Realism embodies a philosophy of change and evolution, and a theory of values. There is no 'proof' for realism "........without assuming realism it is impossible to prove realism" (50). Its temper is a sort of mathematical logic.

As pointed out earlier the discreteness of waves and particles and their duality in one character is reflected in theories of realism. To my mind the idealist concept of degrees of truth and reality to explain finite existence has also probably a similar background. Idealist, however, generally go beyond it. "Existence is not reality and reality must exist" (51) is their well-known slogan. A section of the realists have taken up cudgels against all metaphysics and maintain that the reality lies only in the logical interpretation of all sciences in a sort of universal language (52). They are known as logical positivists and their destructive activities are directed against all metaphysical consideration and their constructive activities are confined to what may be termed as the grammar of science. They are a sort of extremists who have managed to disturb their own patrons by their extremism. Russell remarks, "........complete metaphysical agnosticism is not compatible with the maintenance of linguistic propositions........This view forgets that language is an empirical phenomenon like another, and that a man who is metaphysically agnostic must deny that he knows when he uses a word" (53).

Metaphysical ideas are generalizations of a wider character and it is for this reason that I have tried to trace briefly the idea of the most characteristic property of *Matter* variously designated as change, motion, movement, transformation or flux. It is undoubtedly common to all philosophic theories and may justifiably be called a *universal.* This notion of change, motion, flux etc. involves necessarily the concept of causality. The more generalized is this concept the greater would be the justification for this notion to be called a *universal.* Now I will try to show how the recent alternate interpretation of quantum theory not only removes apparent contradictions in usual scientific theories pertaining to quanta and the so called ultimate particles of matter but provides a glimpse into the nature of possible ultimate *Reality.*

In all domains from infinitely small to infinitely great it is found that there is change, motion, flux, transformation, movement etc. At the same time we notice a chain of causality, sometimes apparent, sometimes hidden. During the course of human observation unaided and aided by instruments the hidden causality is often brought to surface. The process variously called as change, motion, flux etc. is a process of becoming and there are no gaps between becoming and being. The greater the knowledge the lesser is the gap between becoming and being and one could say that becoming is being. At the same time we find that opposite and contradictory are the characters of this change, motion; transformation, flux, movement etc. There is a balance of the opposite and contradictory characters. There are internal influences and external influences and there is generally a balance between them. All these balances may 'unaccountably' be upset by 'chance' and certain new phases may emerge. There is a rule of selection—say natural selection—in all domains. This results in a diversity which is truly infinite. It was shown in part—I (1) how the recent alternate interpretation of quantum theory has led to a more generalized concept of causality which is infinite in its content and scope and thus is able to emphasize the infinity of nature. It has been possible for physical science to trace certain characters in all Matter (living/non-living) and we find that all these characters are infinite in their content and scope. Major features of these ideas are given in a tabular form designated as The Plan.

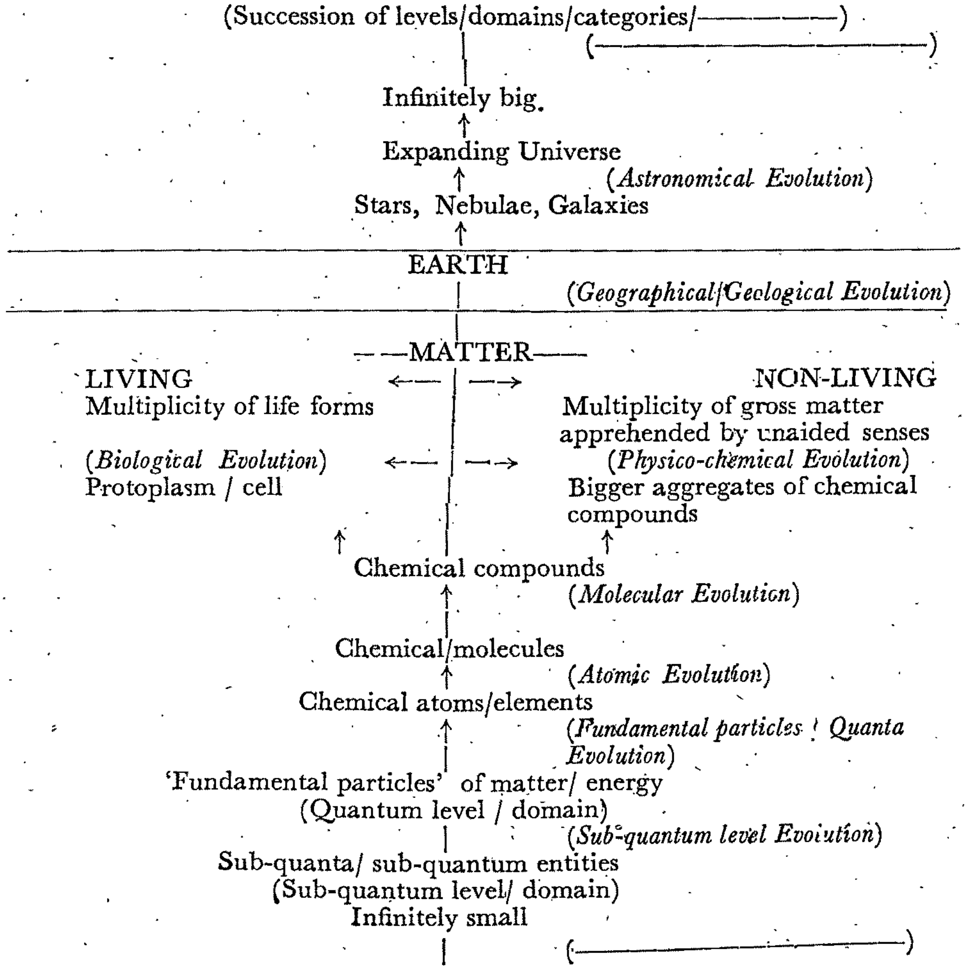
Even though the essential features of the Plan are self explanatory a few words to make it further explicit are necessary.

(*a*) The top of The Plan represents the infinitely big and the bottom infinitely small. There are no limits on either side. The idea of an expanding universe (54) provides a glimpse of the infinitely big. The idea of sub-quantum level entities (55) provides a glimpse of the infinitely small.

(*b*) In between these there are other broad levels which merge into one another. The limits of human observation aided by instruments is able to reach to a point where one begins to get the glimpse of the infinitely small and the infinitely big.

(*c*) Transition from smaller to bigger can be perceived as a sort of *Evolution.* Entities in a lower level in their aggregate provide reality or causation of the next higher level. The properties of sub-quantum level entities may provide natural cause for phenomena at quantum level; the properties of quanta and the so called fundamental particles may provide natural cause for chemical atoms/elements; these in turn lead to chemical molecules; molecules provide the basis for chemical compounds; bigger aggregates of molecules of chemical compounds may lead on the one hand to the primitive protoplasm or the unit cell and to a multiplicity of gross matter apprehended by unaided senses; the cell may give rise to a multiplicity of life forms through biological evolution and gross matter is worked up into various shapes and forms by human beings ; earth itself has undergone geological and geographical evolution; from earth one may proceed to stars, nebulae, galaxies—expanding universe and so on.

The Plan


(Succession of levels/domains/categories/——————)
(——————————)
Infinitely big.
Expanding Universe
(*Astronomical Evolution*)
Stars, Nebulae, Galaxies
EARTH
(*Geographical/Geological Evolution*)
——MATTER——
LIVING
NON-LIVING
Multiplicity of life forms
Multiplicity of gross matter apprehended by unaided senses
(*Biological Evolution*)
(*Physico-chemical Evolution*)
Protoplasm / cell
Bigger aggregates of chemical compounds
Chemical compounds
(*Molecular Evolution*)
Chemical/molecules
(*Atomic Evolution*)
Chemical atoms/elements
(*Fundamental particles / Quanta Evolution*)
'Fundamental particles' of matter/ energy
(Quantum level / domain)
(*Sub-quantum level Evolution*)
Sub-quanta/ sub-quantum entities
(Sub-quantum level/ domain)
Infinitely small
(——————————)

Note: *Evolution* refers to all types of evolution given in the diagram.

There are certain general characteristic features which run throughout The Plan.

(*i*) Causality—Part-I of these studies (1) was entirely devoted to this concept and it was shown that the principle of causality is universal. Here, however, one aspect of it is pertinent. In order to find the cause of a particular phenomenon in a particular domain one has to study the forces working at that level and, in general, first find the laws which may be termed operational laws in that level. But in order to find the deeper cause one will have to go to a level below the level of that domain. This may be illustrated as follows. The laws of quantum domain are best known in the generally accepted quantum mechanics but when these operational laws lead to conflicting results one has to look for causes and is thus led to postulate a sub-quantum level. Most of the chemical reactions take place at atomic level. In fact, atom has been defined as the unit of chemical reactions. In majority of chemical reactions the operational laws of the atomic level are sufficient to provide the requisite explanation but in high energy reactions these laws begin to prove inadequate and one has to go to the lower level of the so called fundamental particles of matter such as electron, proton, neutron etc. To find the cause of the behaviour of chemical compounds one has to go to the lower level of molecules and atoms. In order to find the cause of the beginnings of life one would have to go to a lower level of bigger molecules (55). In scientific studies we are driven to postulate that though life begets life, the origin of life must have a physical basis (56). Blum (57) has rightly pointed out that to define origin of life one must talk about origin of protein. In fact, one who is familiar with the recent scientific discoveries in the border land where non-living passes into living (58), so to say, would agree with Prof. Pirie that it is impossible now to define life in this level (59). It is for this reason that in the diagram a double headed arrow has been placed between cell and bigger aggregates of chemical compounds, and, between living and non-living which are only separated by broken lines.

In the domain of living Man occupies a unique position. In the biological evolution from the primitive protoplasm up to man there are still stages which are in doubt but on the whole the biological evolution is now generally accepted (60). According to this view man "..............is, infact, structurally a rather generalized member of the order of mamals to which he belongs..............a species of vertebrate falling within the placental sub-class of Mammalia, and to the order Primates within that sub-class" (61). It is in the brain that we find the chief difference and this difference is "purely quantitative" (61). Nevertheless this difference is what distinguishes him from all other mammals (62). Even though he is not a model of perfection as far as his bodily built is concerned and takes a rather lowly position among his better designed cohabitants of the earth yet he alone has the brain to be able to have an objective view and to think and argue about it (63).

Man alone has the capacity to understand his own evolution. "Nothing is more free than the imagination of man; and though it can not exceed that original stock of ideas furnished by the internal and external senses, it has unlimited power of mixing, compounding, separating, and dividing these ideas, in all the varieties of fiction and vision" (64).

Earth, its satellite moon and other planets along with stars, nebulae, galaxies are all results of a sort of 'astronomical evolution' (65). The astronomers tell us that this universe is expanding "About every 1,500,000,000 years the universe will double its radius, and its size will go on expanding in this way in geometrical progression forever" (66). All universe makers of astronomy take into account the motions of stars, nebulae, galaxies which appear to be far ever receding from us (67). Their systems are based on the assumption that radiation from the sun or a star is uniformly propagated in space. Professor Soddy questioned the validity of this unverified assumption (68). Inspite of this, astronomy has made progress to indicate that this universe is unlimited and tends to extend to infinity. (*ii*) In each level there are opposite and contradictory forces working. All heavenly bodies such as stars are under going internal changes and perhaps also external changes. The internal changes are reflected in the colours—red, blue, white. The external changes are generally due when two such bodies come nearer together or near enough to cause 'tidal waves' of the type postulated by Professor T.C. Chamberlain in connection with the origin of earth (69). It is in such type of external disturbances that astronomers tell us that one must seek the evolution of our solar system and the origin of the planet earth (70). The earth itself is under going opposite and contradictory changes. There are internal stresses and external changes caused by its atmposphere (71). Such changes are not only confined to this planet but are generally occurring on other planets of the solar system as well (72).

Man himself being on planet earth has mostly studied matter living and non-living on this planet. In the living body we find "..............definite mechanical structures so arranged as to conduce to the maintenance of normal vital activities, or to protect normal living structure; but on close examination these structures, such as bones, skin, lungs etc. are found to be themselves alive either partly or wholly—that is to say, they are constantly being actively maintained by co-ordinated activity..............." (73). The external influences on the living are well known. In the domain of non-living at various levels we find that there are internal forces and external influences. Moreover, the farther lower we go in these levels (molecules, atoms, fundamental particles, quanta, sub-quanta) the more violent are internal motions and always there are extenral forces working.

In general, therefore, one may say that opposite and contradictory forces are the essence of the process of becoming and are synonymous with being itself. They are essential constituents of the stuff—reality.

(*iii*) Various levels which have been mentioned in the diagram called The Plan is in a sense quantization of the whole. The usual interpretation of the quantum mechanics demonstrates that with the instruments made out of ultimate fundamental particles, so to say, we reach a limit beyond which we cannot know about the ultimate particles. In this quantum level the laws must necessarily be statistical as one can only observe discreteness at this level. The aggregates of this discreteness can be satisfactorily described only statistically or by statistical laws governed by the formal rules of mathematics concerning these laws. This kind of idea can be traced in several disciplines *e.g.*, Gestalt psychology roughly assumes that perceptions and ideas are "wholes" not analysable even abstractly into 'parts'—a quantization of perceptions and ideas. Obviously the laws governing these 'wholes' can only be statistical. To make them explicit one would have to go to the level of brain physiology—the working of the brain which is the seat of ideas. We do not know enough about it to correlate it with ideas but it does not mean that it can not be known further. As explained in part-I (1) the recent alternate interpretation of the quantum theory postulates sub-quantum entities in such a manner that the statistical laws governing the quantum level become only natural on that basis. Knowledge of any level generally can be reached only upto the "quantum level" of that level. To go beyond would mean exploration of a domain which necessarily remains merely metaphysical for sometime till a far greater insight is obtained.

It shall now be pointed out that we can get only a glimpse of the *Reality*. Change, motion, movement, flux and so on is an essential factor in the process of becoming and is itself dependent upon time—changing with time. There is a reciprocal relationship between opposite and contradictory internal and external forces and hence at each moment only certain aspects of becoming which is being can be concrete and unique. By studying these aspects one can further one's knowledge of nature but this knowledge can never be free from error in the sense that it can never be absolute. The only absolute truth is that there is no absolute truth in the sense that there is no absolute content to our knowledge. Infinite totality of matter in the process of becoming, the process itself dependent upon time—the reciprocal relationship of various forces leading to infinite multicplicity, leads to a glimpse of the nature of *Reality*. It would only remain a glimpse which may become more and more penetrating with time until somebody succeeds in working out the mathematics of infinities—and if that be never possible, the only way to realize it would be in absolute experience, something which can not be expressed in language as it goes beyond the quantization of language—the words. This is what I would like to term the unique, absolute *Reality*.

Knowledge is divided into various disciplines which in a sense is quantization of knowledge. Each discipline in its turn can lead to the study of a part of the *Reality*. Since the part itself is infinite a particular discipline can ultimately provide a glimpse of the reality of this part or facet of *Reality*. Such glimpses when compounded would provide a glimpse of *Reality*—the unique, the absolute, the whole. Such compounding, so to say, is the content of philosophy. Various isms would necessarily depend on certain aspects and would provide only a glimpse of the whole. There would be ideas, sayings, aphorisms in various isms which would in one sense or other be applicable to REALITY. Various schools of thought are based and would continue to be based on observations of one type or another. There is bound to be a background symphony in every ism and if present is any indication of the future, this symphony would consist of concepts, ideas, knowledge in the sphere of what is generally called science.

Man always wishes to go beyond. "Whatever he reaches he wishes to go beyond. If he reaches the sky he wishes to go beyond" (74). It is a remarkable tribute to the genius of man to be able to get a glimpse of *Reality* as he himself is not apart from it and can not be wholly objective by the nature of things. It is enjoined in Bhagvadgīta that the only true knowledge is to realize a unity among diversity (75). This unity which has been termed here *Reality* is such that we can get only a glimpse of it, a glimpse which points to its infinity. Well did the Upaniṣad say—"The infinite is bliss, there is no bliss in things finite" (76).

SUMMARY

An attempt has been made to generalize the basic concepts of physical science about matter to lead to the conclusion that there exists an absolute, unique, objective *Reality*, which can only be observed in parts and which forever would remain unknown in its totality. The nature of this *Reality* is such that we can get only a glimpse of it—a glimpse which points to its infinity.

REFERENCES

1. Perti, O.N. This *Journal*, pp. 1 to 17.
2. Joad, C.E.M. 1932, *Philosophical Aspects of Modern Science*, 293.
3. Remarks in the collection, 1949, Albert Einstein, *Library of Living Philosophers*, pp.684
4. Bohm, D. 1952, *Phys. Rev.*, **85**, 166; *Ibid* 684.
5. Bohm, D. 1957, *Causality and Chance in Modern Physics*, pp.. 80.
6. Korner, S. 1958, *Observation and Interpretation*, an account of the symposium.
7. Hiriyanna, M. 1932, *Outlines of Indian Philosophy*, 17, Cf. RV.I.124.2.
8. Radhakrishnan, S. (Ed.), 1953, Concluding survey, *History of Philosophy Eastern and Western*, 440.
9. Clifford, W. K. 1946 (New Ed.), *The Common Sense of Exact Sciences*; quotation in the beginning from *Aims and Instruments of Scientific Thought*.
10. Jeans, J. : *The Mysterious Universe*, 44.
11. Whitehead, A.N. 1925, *Science and the Modern World*, pp. 75.
12. Radhakrishnan, S. 1951 (Reprint Indian Ed.), *Indian Philosophy*, I, 553.
13. Joad, C. E. M. 1932, *Philosophical Aspetcs of Modern Science*, 325.

14. Radhakrishnan, S. 1951 (Reprint Indian Ed.), *Indian Philosophy*, **I**, 555
15. Westaway, F.W. 1934, *The Endless Quest*, 945.
16. Eddington, A.S. : *The Nature of the Physical World*, 254.
17. Hiriyanna .M. 1932, Sankhya-yoga, *Outlines of Indian Philosophy*, 271.
18. Dasgupta, S. 1951 (reprint), *A history of Indian Philosophy*, **I**, 310.
19. Das, R.V. 1953, Existentialism, *History of Philosophy Eastern and Western*, chap. XLVIII, 427.
20. Nikam, N.A. 1953, Realism, *History of Philosophy Eastern and Western*, Chap. XLV, 389.
21. See Laird : *A Study in Realism*, pp. 8.
22. Emmet, D. : *Whitehead's Philosophy of Organism*, 79.
23. Broad, C.D. : *Scientific Thought*, 39.
24. Radhakrishnan, S. 1951 (reprint Indian ed.), *Indian Philosophy*, **I**, 78.
25. See Deussen : *System of the Vedanta*, pp. 18.
26. Dasgupta, S. 1951 (reprint), *A History of Indian Philosophy*, **I**, 53.
27. Ranade, R.D. & Kaul, R.N. 1953, Pre-Socretics, *History of Philosophy Eastern and Western*, **II**, Chap. XXVII, 32.
28. Radhakrishnan, S. 1951 (reprint Indian ed.), *Indian Philosophy*, **I**, 375.
29. *Ibid.*, 371.
30. *Ibid.*, 374.
31. *Ibid.*, 372.
32. *Ibid.*, 367.
33. *Ibid.*, 368.
34. *Ibid.*, 369.
35. *Ibid.*, 372.
36. *Ibid.*, 369.
37. *Mahabharat*, Striparva, 13.
38. *Bhagvadgita.*, II.28.
39. *Ibid.*, III. 5.
40. Dasgupta, S. 1951 (reprint), *A History of Indian Philosophy*, **I**, 47.
41. Seal, B.N. 1915, *Positive Sciences of Ancient Hindus*, 7.
42. Radhakrishnan, S. 1951 (reprint Indian ed.), *Indian Philosophy*, **I**, 371.
43. Naidu, P.S. 1953, Evolutionism, *History of Philosophy Eastern and Western*, Chap. XLIV, 355.
44. Joad, C.E.M. 1937 (new ed.) The Philosophy of Change, *Great Philosophies of the World*, Chap. VI, 121, 123.
45. See Morgan, C.L. 1923, *Emergen Evolution.*
46. Whitehead, A.N. : *Science and the Modern World*, 112
47. Broad, C.D. : *Scientific Thought*, 267-68.
48. Laird : *A Study in Realism*, 12.
49. Whitehead, A.N. : *Essays in Science and Philosophy*, 39
50. Nikam, N.A. 1953 Realism, *History of Philosophy Eastern and Western*, Chap. XLV. 378.
51. Bradley, F.H. : *Appearance and Reality*, 400.
52. See Morris, C.W. 1937, *Logical Positivism, Pragmatism and Scientific Empiricism.*
53. Russell, B. : *An Enquiry into Meaning and Truth*, 347.
54. Eddington, A.S. : *The Expanding Universe.*
55. Oparin, A.I. 1953 (reprint), *The Origin of Life.*
56. Bernal, J.D. 1951, *The Physical Basis of Life.*
57. Blum, H.F. 1951, *Time's Arrow and Evolution.*
58. See the following :
    1957, Modern ideas on spontaneous generation, *Annals of New York Academy of Sciences*, **69**, Art. 2.
    1957, *Origin of Life on Earth*, report of International Symposium held in Aug., 1957, at Moscow : Ed. G.A. Deborin.

59. Pirie, N.W. : The meaninglessness of the terms 'Life' and 'Living', *Perspectives i Biochemistry.*
60. Jeans, Bower, Mac Bride, Jeffreys etc. : *Evolution in the Light of Modern Knowledge.*
61. Osman-Hill, W.C. 1957, *Man as an Animal.*
62. Heinz, G. 1957, *Man Unlimited* (translated by Richard and Clara Winston).
63. 1957 (May, 10), Unlimited Liability, *The Times Literary Supplement*, 281-82.
64. Hume, D. 1938, An Enquiry Concerning Human Understanding, *Harvard Classics*, **37**, 324-325.
65. Hoyle, F. 1950, *The Nature of the Universe.*
66. Eddington, A.S. : *The Expanding Universe*, 23.
67. Knox, H. 1933, *Distances and Motions of Extra Galactic Nebulae*, Address to Royal Astronomical Society.
    Milne, E.A.1932, World Structure and the Expansion of Universe, *Nature* (22nd July).
68. Soddy, P. 1931 (21s Feb., 5th Sept.), *Nature.*
69. Chamberlain, T.C. : *The Origin of the Earth.*
70. Moulton, F. R. : *Evolution of the Solar System.*
71. Jeffreys, H. : *The Earth.*
72. Richardson, R.H. 1956, *Man and the Planets* (Book Club. ed.)
73. Haldane J.S. : *The Sciences and Philosophy*, 69.
74. *Katha*,ii,2-3.
    Radhakrishnan, S. 1951 (reprint Indian ed.), *Indian Philosophy.* **I**, 213.
75. Bhagvadgita, XVIII. 20.
76. *Chan.*, vii, i, 24.

DEVELOPMENT OF TRICHOMES IN SALVIA R. BR.

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INTRODUCTION

The Anatomy of several species of *Salvia* has already been studied : *S. sclarea* (Muller, 1890); *S. mellifera* (Solereder, 1911); *S. horminum* (Haberlandt, 1914); *S. argentea* (Volkens and Gregory Haberlandt, 1914); *Salvia* sp. (Lemesle, 1926); *S. officinalis* (Metcalfe and Chalk, 1950); and *Salvia* sp. (Esau, 1953). A special mention may be made of the work of Etienne (1930) on *S. broussonetii* collected from the Canary Islands. In this paper observations on the development of trichomes of *S. plebia* have been recorded.

MATERIAL AND METHODS

The material of *S. plebia* was collected locally in January 1956, and fixed in formalin-acetic-alcohol. Customary methods of microtechnique were followed. Serial transverse and longitudinal sections 12-20 μ thick were cut and stained with safranin and fast green. Free-hand sections stained in safranin and mounted in glycerine jelly were also examined.

OBSERVATIONS

Trichomes. As Metcalfe and Chalk (1950) indicate the trichomes afford valuable information for the identification of genera and species. Usually the trichomes distributed on the leaf and the flower buds are of the glandular type. Haberlandt (1914) states: "floral organs are frequently provided with dermal glands secreting fragrant volatile esters which help to attract insect visitors for the cross pollination". This statement is specially applicable to a plant like *Salvia.* Both glandular and nonglandular trichomes occur on various organs of *Salvia plebia.*

A. NON-GLANDULAR TYPES

(i) *Short trichomes.* Short uniseriate trichomes are very common on young leaves, stem and calyx. On the calyx they do not elongate much and remain three to four cells in height, whereas on stem they may have six cells. In the beginning the hair initial is not very conspicuous from the other epidermal cells but when the former bulges out (Fig. 1) it becomes distinguish-

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able. This cell and its derivatives divide only transversely, and the nuclei and the cytoplasm remain prominent for a long time. The apical cell does not become pointed but remains rounded and probably performs a secretory function (Fig. 2).

(ii) *Long trichomes.* These are different from the short trichomes only in their length, but probably not in their function. The development corresponds to the short trichomes resulting in three, four, or more cells in height. The apical cell is much pointed and non-secretory. As the hair matures, nucleus of each cell collapses and the scanty cytoplasm lines the cell walls. The type of hair shown in Fig. 5 is very common on calyx and floral stalks (Figs. 4-6). Similiar hairs are abundant on the four angles of the stem, and are mostly three to four cells in height bearing minute papillae (Fig. 3).

(iii) *Sickle-shaped trichomes.* Sickle-shaped trichomes are uniseriate and two to three cells in height, the two-celled condition being more common. The hair initial divides transversely and the outer cell soon starts elongating. There is another transverse division thus making the trichome two-celled, but there may be one more division in the lower cell so that it becomes three-celled. The apical cell takes on the characteristic shape of a sickle (Figs. 7-9).

(iv) *Curved trichomes.* Curved uniseriate trichomes were observed only on young sepals, and were uncommon on other parts of the plant. They develop from the upper cell cut of by the initial (Fig. 11). Two or rarely three cells may be produced by transverse divisions. In this case all the cells are almost of the same size (cf. Figs. 7-9). The nuclei disappear early and there is hardly any trace of cytoplasm or any secretory substance so that these trichomes are non-secretory (Fig. 10-11).

B. GLANDULAR TYPES

The tip and the stalk of the glandular trichomes have a varying number of cells and the amount of secretory product in the apical cells. They seem to be ephemeral and the following types have been recorded.

I. SHORT-STALKED CAPITATE GLANDS:

(i) *Head unicellular, stalk one-celled.* These are common on the abaxial surface of calyx and young stem and consist of a stalk cell and a conspicuous vescicular apical cell containing dense cytoplasm and a large prominent nucleus. An unusual feature is the presence of a notch on one side of the tip which is probably responsible for the discharge of the secretion (Fig. 12).

(ii) *Head bicellular, stalk two-celled.* Such trichomes are very common on young stems and have a two-celled stalk. The nucleus and cytoplasm together with secretion are quite prominent in the apical and the adjacent cell(Fig. 13).

(iii) *Head 4 to 8-celled, stalk one-celled.* These trichomes are present on very young stem and they have a 4 or 8-celled apical cell. The initial cell is conspicuous by its large size, dense cytoplasm and prominent nucleus (Fig. 14). To begin with, it divides transversely so that a tier of two cells is formed. The next two divisions in the apical cell take place vertically at right angles to each other, resulting in the formation of four cells. Another division in the same plane in each of these four cells produce a 8-celled head (Figs. 17a-18a). These divisions may or may not be synchronous. The head cells are conspicuous due to the presence of large nuclei, dense cytoplasm and secretory product (Figs. 14-18).

II. LONG-STALKED CAPITATE GLANDS:

(i) *Long-stalked glandular trichomes.* This type of trichome is quite common on the floral stalks and consists of a unicellular apical cell. The swelling of the apical cell and the accumulation of secretion starts quite early. At the apex a notch is differentiated which becomes prominent when the secretion starts oozing out and ultimately the upper part of the apical cell collapses. The stalk grows up to five or more cells in height, though three-celled condition is more common. Probably, at this stage the trichome temporarily stops further development to resume the next division (Figs. 19-21).

Sometimes the initial cell or its derivatives divides transversely producing three, four or even more cells forming a uniseriate trichome where the apical cell does not swell (cf. Fig. 19). The swelling and the accumulation of secretion takes place when it has become four to five cells in height (Figs. 22-24).

SUMMARY AND CONCLUSIONS

The trichomes of *Salvia plebia* R. Br. are somewhat different from those of other species described so far. The walls of the trichomes are not lignified but are composed of cellulose and not strongly cuticularised. Branched or tufted multicellular hairs were not observed in this species. The stalks of trichomes with 8-celled apical cell are usually short, though longer stalks have been reported in a few species of *Salvia* (Metcalfe and Chalk, 1950). An unusual feature observed in *Salvia plebia* is the presence of a notch in the apical cell of two-celled trichomes. Other interesting forms of trichomes met with in this species are 'sickle-shaped' and 'curved uniseriate' types, and thus these names have been suggested. So this species can be distinguished from others by characteristic trichomes.

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EXPLANATION OF THE FIGURES

Figs. 1—11: Non. glandular Trichomes.

- Figs. 1—2. Development of short trichomes X 360.
- Fig. 3. Trichome on the stem X 240.
- Figs. 4—6. Development of long trichomes Figs. 4 and 5 X 360. Fig. 6 X 240.
- Figs. 7—9. Development of sickle-shaped trichome X 240.
- Figs. 10—11. Development of curved trichome X 360.

Figs. 12—24. Glandular Trichomes.

Short-stalked capitate glands.

- Fig. 12. Head unicellular, stalk one-celled X 350.
- Fig. 13. Head bicellular, stalk two-celled X 360.
- Fig. 14—18. Development of trichome with 4 to 8-celled and stalk one-celled. Fig. 14 X 1200, Figs. 15—18 X 216.
- Figs. 17a—18a. T. S. of head cell in 2 and 3-celled stages of development X 360.

Long stalked capitate glands.

- Figs. 19—24. Long-stalked glandular trichomes X 360.

REFERENCES

1. Eames, E. A. & MacDaniels, L. H. 1947. An Introduction to Plant Anatomy. New York.
2. Esau, K. 1950. Plant Anatomy. New York.
*3. Etienne, R. 1919. *Contribution a l etude structurale des Labiees endemiques des I les Canaries.* Thesis. Paris p. 159.
4. Haberlandt, G. 1914. Physiological Plant Anatomy. London.
*5. Lemesle, R. 1926. *Sur l existence dun rhytidome chez certaines Labiees. Bull. soc. bot. Fr.* **73**, 983-6.
6. Metcalfe. C. R. & Chalk, L. 1950. Anatomy of the Dicotyledons, Clarendon Press, Oxford.
7. Sen, D. N. 1959. Ecological Studies of Aquatic and Swampy vegetation of Gorakhpur, *Agra Univ. Jour. Res. (sci.)*. **8** (1); 17—29.
*8. Solereder, H. 1911. *Zur mikroskopischen pulveranalyse der Folia Sclviae* Arch. Pharm. Berl. **249**, 123-7.

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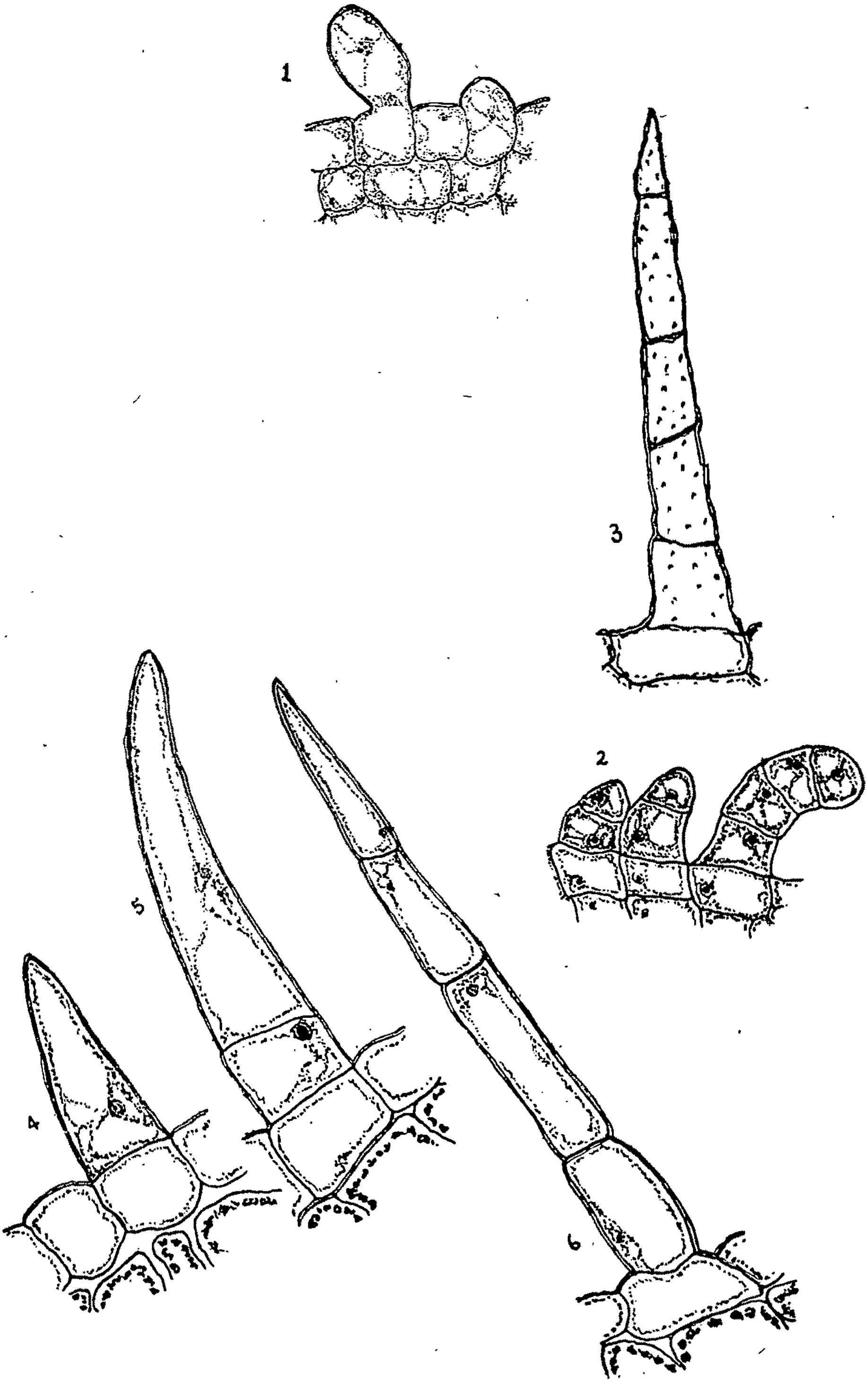
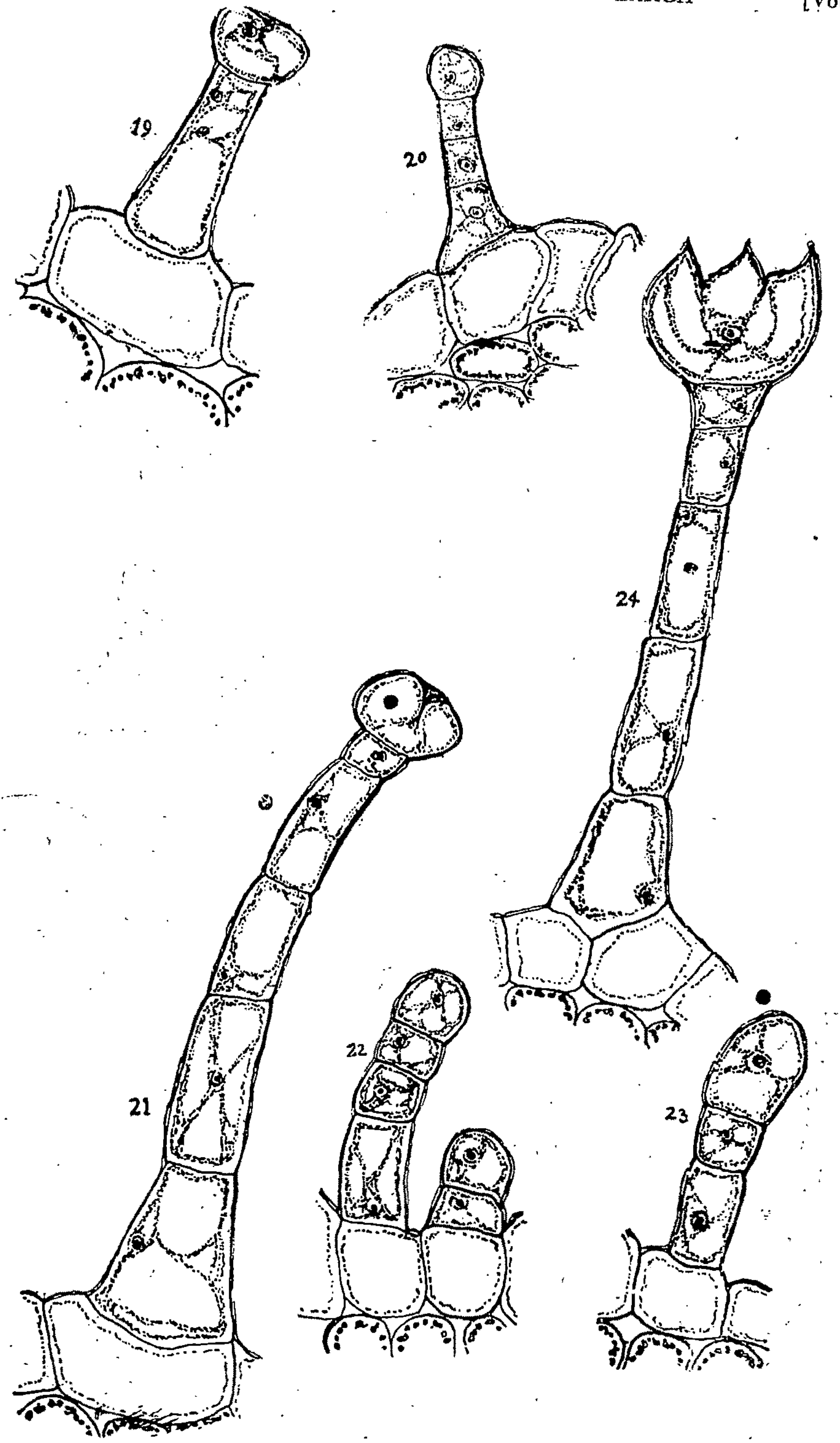
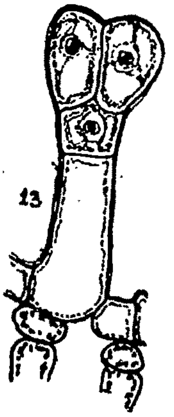
* Not seen in original.



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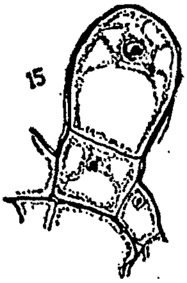
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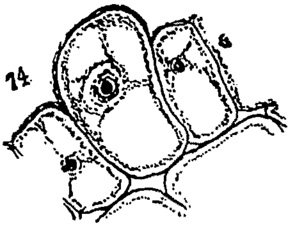
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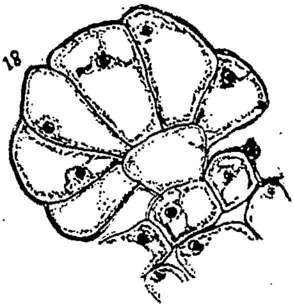
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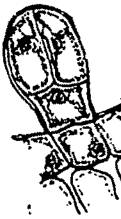
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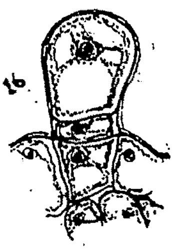
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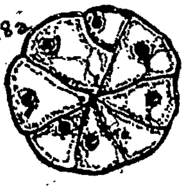
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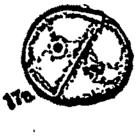
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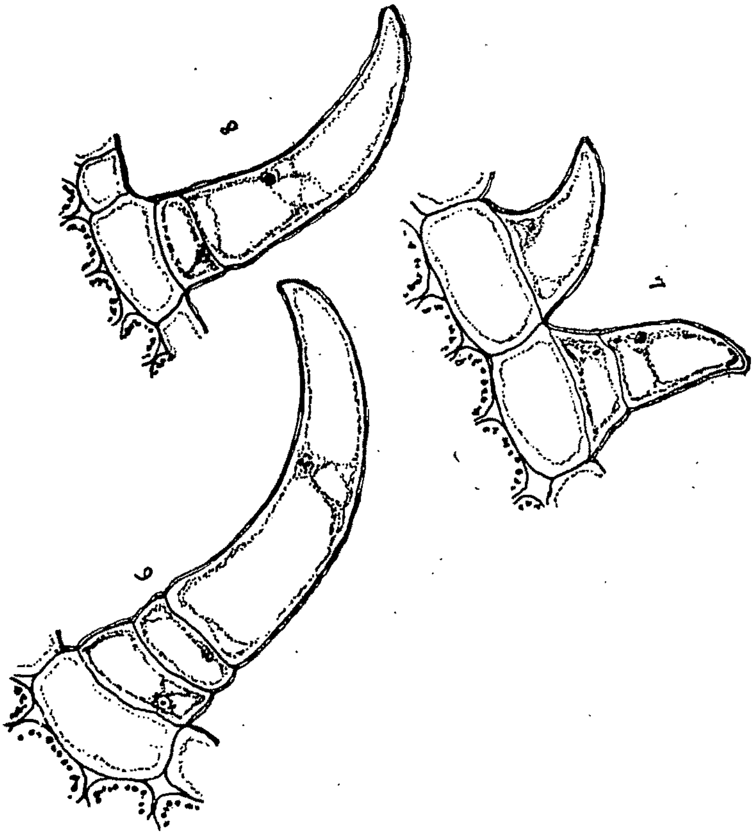

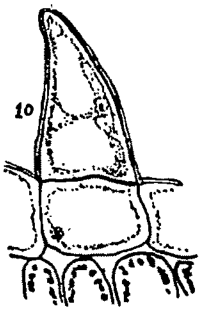
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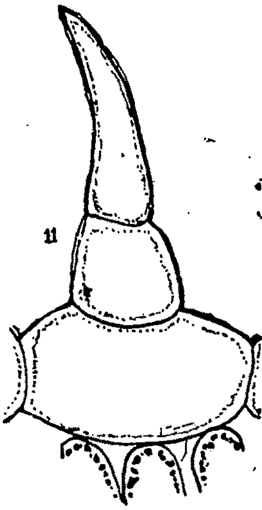
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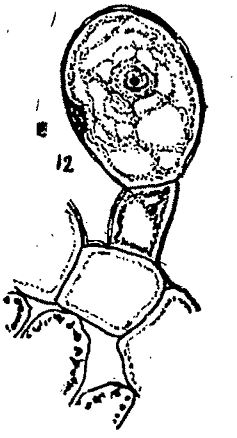
12

SOIL MOISTURE REGIME OF THE DEMONSTRATION AREA, FOREST RESEARCH INSTITUTE, DEHRA DUN

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The total precipitation of a region and its monthly variation have a pronounced influence on the growth of vegetation. Variety of factors operate together in determining the effective moisture regime in the soil, which ultimately governs the existance, development and reproductive capacity of the vegetation.

Thornthwaite (1948) evolved a series of climatic formulae to correlate the atmospheric changes with the occurrence of vegetation. Leeper (1950) modified Thornthwaite's formula to suit conditions in Australia. This modified formula seems suitable for applicability, under Indian conditions. Leeper's formula reads as :

$$Et = 4.4\ S + (T - m)$$

Where Et=Evapotranspiration measured in millimeters

S=Saturated vapour pressures at mean monthly temperature (T), in m. m. of Hg.

T=Mean monthly temperature in °F

m=Mean annual temperature in °F

Accordingly, the mean values for precipitation, temperature and evapotranspiration were calculated for the demonstration area of the Forest Research Institute, under *Shorea robusta*, for the period from June 1956 to February 1958 and the results are shown graphically in the figure attached, which clearly indicates the periods of available moisture for plant growth *viz.* moisture stored in the soil, stored moisture utilized, restricted moisture available and moisture deficiency.

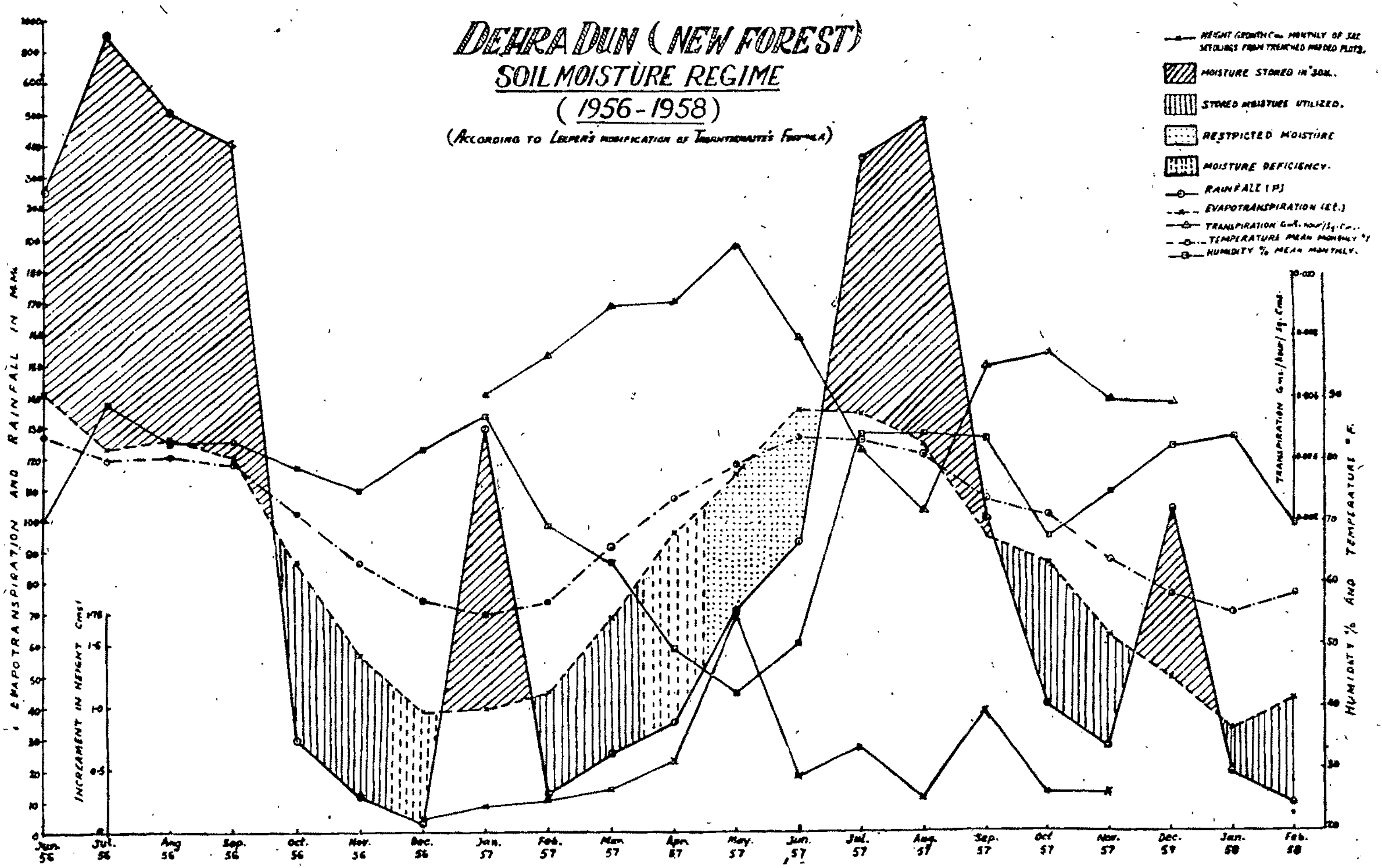
This graph, explicitly indicates the soil moisture regime and clearly differentiates the periods of available moisture for plant growth.

When the precipitation exceeds the evapotranspiration, the maximum amount of moisture which can be retained in the soil for plant growth, is 4 inches (approx. 102 m. m.). The balance is lost either as run-off or drainage. This stored moisture become available to plants in the following periods of moisture deficiency, if necessary. When the evaporation exceeds the precipitation, varying conditions of deficiency of moisture are caused. Even under such deficient moisture conditions, if the monthly precipitation is 2 inches (approx. 51 m. m.) or more, restricted amount of moisture remain available for plant growth. But when the monthly precipitation is less than 2 inches, real drought conditions prevail.

I am grateful to Sri S. K. Seth and Sri M. A. W. Khan, for helpful suggestions.

REFERENCES

1. Bhatnagar, H. P. 1958. Ecologico physiological studies on sal (*Shorea robusta*) forests. *Agra Univ. Ph. D. Thesis.*
2. Leeper, G. W. 1950. Thornthwaite's climatic formula. *Jour. Australian Inst. of Agric.* Sc. **6** (1), 2-6.
3. Thornthwaite 1948. An approach towards the rational classification of climate *Geo. Rew.* **38**: 55-94.


DEHRA DUN (NEW FOREST)
SOIL MOISTURE REGIME
(1956-1958)
(According to Leeper's modification of Thornthwaite's Formula)
HEIGHT GROWTH Cm. MONTHLY OF SAL SEEDLINGS FROM TRENCHED WEEDED PLOTS.
MOISTURE STORED IN SOIL.
STORED MOISTURE UTILIZED.
RESTRICTED MOISTURE
MOISTURE DEFICIENCY.
RAINFALL (P)
EVAPOTRANSPIRATION (Et.)
TRANSPIRATION Gm. hour/Sq. Cm.
TEMPERATURE MEAN MONTHLY °F
HUMIDITY % MEAN MONTHLY.
EVAPOTRANSPIRATION AND RAINFALL IN MM.
INCREAMENT IN HEIGHT Cms.
TRANSPIRATION Gms./hour/Sq. Cms.
HUMIDITY % AND TEMPERATURE °F.
Jun. 56
Jul. 56
Aug 56
Sep. 56
Oct. 56
Nov. 56
Dec. 56
Jan. 57
Feb. 57
Mar. 57
Apr. 57
May 57
Jun. 57
Jul. 57
Aug. 57
Sep. 57
Oct 57
Nov. 57
Dec. 57
Jan. 58
Feb. 58
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
300
400
500
600
800
1000
0.5
1.0
1.5
1.75
0.000
0.002
0.004
0.006
0.008
0.010
20
30
40
50
60
70
80
90

II. EFFECT OF SOWING AT DIFFERENT DATES ON THE GROWTH AND FLOWERING OF ANTIRRHINUM, SWEET SULTAN AND HELIPTERUM.

P. N. Bajpai and V. N. Nerikar

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Bajpai and Nerikar (1959) reported on the suitable time for sowing of Cosmos, Caryopsis and Larkspur. The work was further carried on some more winter season annuals with a view to study the effect of sowing at different dates. The annuals were antirrhinum (*Antirrhinum majus*), Sweet Sultan (*Centaurea moschata*) and *Helipterum* Sp.

Twenty seeds of each of these annuals were sown in pots at an interval of ten days commencing from 20th August to 29th October at the Agricultural College, Kanpur. The viability of the seeds at the sowing time was 82% in Antirrhinum, 86% in Sweet Sultan and 88% in Helipterum. The seeds took about seven to ten days for germination and the seedlings were transplanted twenty one days after in each treatment.

Antirrhinum

The germination of the seeds was found satisfactory from the last week of September to the end of October when the minimum night temperature was about 18.8°C and before that period there was no germination. There was high mortality (11%) of seedlings due to damping off in the earlier germinations but best results were obtained in the mid October sowings when the night temperature fell to about 12.1°C.

The plants in all the treatments attained a characteristic height (more than 24") and there was no appreciable difference in the flower size in the various treatments. But the number of flowers per spike was more in those plants which were raised from seeds sown earlier (Last week of September, and first week of October). It seems that antirrhinum is well adapted to the cool season and hence it should be sown after first week of October when the season is fairly cool and night temperatures go down.

Helipterum sp.

The germination of helipterum seeds was fairly high in all the sowings. But there was a little mortality (13%) of the seedlings in the pots sown between 20th and 30th August due to wilting and damping off and the seedlings also did not look very healthy. The number of tillers as well as the number of flowers per plant was more in the earlier sowings (August & September) than in the later ones. Thus it can be sown even in warm weather and for mass effect it should be sown earlier.

The flowering started after 107 days of the germination of the seed. Large sized flowers were produced on the plants raised from sowing made between September and October but the duration of flowering was found longer in the earlier sowings only. Thus it seems that *Helipterum* seeds can be sown from August to October according to the needs of an individual.

SWEET SULTAN

There was a vide variation in the germination of Sweet Sultan seeds under different dates of sowing but the best germination was obtained in the sowings made between 30th August and 9th October and in subsequent sowings the mortality of the seedlings was fairly high (15%). A temperature range between 35.5°C to 19.0°C proved suitable for good germination. In the sowing made on 20th August the mortality of seedlings was mainly due to sun burn.

Plants from the sowings made between 20th August and 19th September made a rapid vegetative growth as compared to other sowings. The stem diameter of these plants was also more and this resulted in increased branching of the plants, with the result that these plants produced largest number of flowers per plant. But the flowers from late sown plants were found bigger than the flowers obtained from the earlier sown ones. But in general the size of the flowers in all the treatments invariably decreased as the flowering season advanced. Flowering started seventy days after the germination of seed in all the treatments. Hence Sweet Sultan may be sown from 30th August to 19th September to get maximum number of flowers per plant but if large sized flowers are desired it may be sown after the second week of October.

REFERENCES

Bajpai, P. N. and V.N. Nerikar (1959) Effect of sowing at different dates on the growth and flowering of Cosmos, Caryopsis and Lar spur. *Science and Culture*, 25 : 140-142.

STUDIES ON STAPHYLOCOCCI WITH PARTICULAR REFERENCE TO STRAINS FROM BOVINE UDDER

II COAGULASE ACTIVITY*

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Loeb (1903-4) was first to recognise plasma clotting phenomenon exhibited by certain strains of Staphylococci. Later Much (1908) while confirming Loeb's observation, expressed that this was an attribute of only pathogenic strains. Although some of the workers (Christie *et. al.* 1946; Marks, 1952 and Selbie and Simon, 1952) considered alpha haemolysin production a more reliable index of pathogenicity, yet the value of coagulase test in differentiating pathogenic and non-pathogenic strains of Staphylococci is recognised by a large number of workers (Cruickshank, 1937; Hallman, 1937; Cowan, 1938; Chapman *et. al.* 1938; Blair, 1939; Plastridge *et. al.* 1939; Smith, 1947 and others).

Different authors had divergent opinions about the suitability of the plasmas from different species of animals and also about the results obtained after adopting different techniques of the test.

Most of the authors reported human and rabbit plasmas most suitable for coagulase test. Cruickshank (1937) found human plasma giving better results than rabbit plasma and Horse and guinea-pig plasmas clotted more quickly than ox and sheep plasmas. According to Klatt (1954), for bovine mastitis strains, plasmas from human and rabbit were best, from horse and pig less suitable and from cattle unreliable. Nakagawa (1958) found rabbit plasma the best, horse and sheep plasmas quite suitable and cow plasma unreliable for bovine udder strains.

Field and Smith (1945) reported human, bovine, mouse, rabbit or cat plasmas to be quite suitable for slide test, while dog, pig, horse and guinea-pig plasmas were unreliable. Employing rabbit plasma Taylor and McDiarmid (1948) found an absolute correlation between the tube and plate tests, although ox and sheep plasmas gave different results in this respect. Selbie and Simon (1952) noted mouse plasma giving comparable results to that of human plasma by the slide method but in the tube test, it was found to be much weaker. Clapper and Wood (1954) reported rabbit plasma giving more positive results than human plasma using tube technique. On the plate, the results obtained by human plasma were equal to that of the tube test when carried out with rabbit plasma.

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* This paper is a portion of the research work carried out by B. S. Malik in partial fulfilment of the requirements for the degree of M. V. Sc. in advanced Bacteriology of the Agra University.

Penfold (1944) introduced plate coagulase test. Out of 100 coagulase positive strains studied by him, 94 showed good rings of opacity, 2 gave poor rings, 3 variable and 1 showed no ring at all. Plate technique of coagulase test was later on followed by Reid and Jackson (1945), Smith (1947), Taylor and McDiarmid (1948), Gorrill (1951) and Lack and Wailling (1954).

The slide technique of Birch-Hirschfield (1934), Berger (1943) and Cadness-Graves *et. al.* (1943), was later on adopted by other workers (Field and Smith 1945; Williams and Harper, 1946; Smith, 1947; Selbie and Simon, 1952; Gillespie and Alder, 1952 and Lack and Wailling, 1954). Cadness-Graves *et. al.* in the beginning found good correlation between slide and tube test results, but in their latter series out of 860 strains, 558 were positive by tube test and only 472 by slide test. Gillespie and Alder (1952) reported 121 strains positive by tube test and 118 by slide test out of 179 strains. Smith (1947) found cent per cent correlation in the results of tube, plate and slide techniques with the exception of 3 strains which gave unsuitable results by slide method.

In an earlier paper the authors (Malik and Singh, 1959) studied various biochemical activities of Staphylococci. The present investigation is attempted to elucidate the comparative value of the plasmas from different species of animals using tube technique. The results obtained by tube, plate and slide techniques were also compared.

MATERIALS AND METHODS

Strains. One hundred and fifty two strains (138 strains from bovine normal and abnormal milk samples, ten from caprine mastitis cases, one from a case of ovine abscess and three fromhuman pathological lesions) isolated at different parts of India, were studied. All 152 strains were first tested for coagulase production using rabbit, sheep, goat, cow, buffalo and horse plasmas. Later on 71 of these strains and 29 obtained from Madras, were compared, employing the tube, plate and slide techniques using rabbit plasma.

Techniques

(a) Tube test—The technique described by Williams and Harper (1946) was followed :

One loopful of 24 hour old nutrient agar slant culture of each strain emulsified in about 1 ml. of citrated plasmas (diluted 1 in 10 of N.S.S.) of rabbit, sheep, goat, cow, buffalo and horse separately in Wasserman's test tubes was incubated at 37°C for six hours and observed at 2 hourly intervals. Positive and negative controls were employed simultaneously. The tubes were later on left at room temperature, a final reading being recorded on next day morning. Tubes showing no clot or showing a granular appearance, were recorded as negative while those giving complete clots or clots with a little supernatent plasma, were noted as positive.

(*b*) *Plate test*—The technique, described by Taylor and McDiarmid (1948) was adopted with slight modifications :

Undiluted citrated rabbit plasma was added to melted nutrient agar (50°C) to give a final strength of 20%. One per cent sterilized acquous solution of neutral red was also added to the above medium to give its final concentration of 0·1%. The addition of neutral red facilitated a better contrast in reading the zones of opacity around the colonies with the rest of the medium. Twelve ml. of the medium thus prepared was poured in petri dishes of four inch diameter. After setting the medium, the petri dishes were dried in the incubator for about thirty minutes and spot inoculated. Twelve strain were inoculated in each plate and results were noted after 24 hour incubation at 37°C.

(*c*) *Slide test*—The technique was the same as described by Cadness-Graves *et. al.* (1943).

On a clean slide in a drop of distilled water, small amount of fresh solid culture was mixed to have a faint opacity. To this emulsion one drop of fresh undiluted rabbit plasma was mixed and the result read within half a minute. Positive strains showed clear clumps of organisms. The results were also verified under low power microscope.

RESULTS

By the tube technique out of 152 strains, only 48 gave positive results in rabbit plasma. Coagulase positive strains among 138 bovine udder strains in rabbit plasma were 42, in sheep plasma 40, in goat plasma 37, in cow plasma 37, in buffalo plasma 36 and in horse plasma 41. (Table I).

Table 1

The results of coagulase test at different time intervals among 138 bovine udder strains using different species of plasmas.

Species of Plasma	No. of positive strains					Percentage
	2 hours	4 hours	6 hours	24 hours	Total	
Rabbit	18	21	2	1	42	100
Sheep	16	16	5	3	40	95.2
Goat	2	14	11	10	37	88.1
Cow	3	3	23	8	37	88.1
Buffalo	—	20	11	5	36	85.7
Horse	—	2	29	10	41	97.6

It can be inferred from table I above that the maximum number of coagulase positive strains were detected in rabbit plasma. The fficacy of the plasmas of other species of animals in order of merit being that of horse, sheep, goat and cow and buffalo respectively. The plasmas of goat and cow showed equal number of coagulase positive strains. Plasmas of different species of animals differed greatly with regard to their clotting period. In this respect plasmas which gave best results were of rabbit and sheep; next to these being goat, buffalo, cow and horse respectively. Maximum number of coagulase positive strains in cow and horse plasmas gave results after six hours of incubation. None of the coagulase positive strains clotted buffalo and horse plasmas within first two hours of incubation, although more than half of the strains clotted buffalo plasma within next two hours of incubation. Considering the efficacy of rabbit plasma as 100%, the results among horse, sheep, buffalo and goat and cow plasmas were 97.8%, 95.2%, 85.7% and 88.1% respectively. The horse plasma clots were soft and gelatinous although they were quite firm and solid from other species of animals.

Out of ten caprine strains only three showed coagulase positive results in rabbit plasma and one in horse plasma. The plasmas from other species were insusceptible.

Out of the three human strains under study only two gave positive results in rabbit plasma and one in horse plasma. There was no reaction in other plasmas.

The results of 100 strains were compared by adopting tube, plate and slide techniques in rabbit plasma. Forty of these strains were positive by tube test, 39 by plate test and 34 by slide test (Table II).

Table 2

Comparative value of the tube, plate and slide coagulase tests of 100 strains of bovine udder Staphylococci.

Place of isolation	No. of Strains	Tube test					Plate Test			Slide test	
		2 hrs.	4 hrs.	6 hrs.	24 hrs.	– ive	Marked opacity	Weak opacity	– ive	+ ive	– ive
Mathura	58	17	10	1	—	30	26	2	30	25	33
Lucknow	6	—	4	1	1	—	6	—	—	5	1
Calcutta	7	—	1	—	—	6	1	—	6	1	6
Madras	29	1	2	—	2	24	2	2	25	3	26
Total	100	18	17	2	3	60	35	4	61	34	66
Percentage of + strains		40					39			34	

On plate test most of the strains gave opacity rings varying from three to four mm. in width from the periphery of the colony. The coagulase positive strains obtained from Madras showed less clear rings by plate test, although they gave pretty good results by slide test.

DISCUSSION

It would be seen from table I that bovine udder strains examined during this study had slightly variable coagulating properties in the plasmas of different species of animals. These strains gave good results in rabbit plasma, fairly good in horse and sheep plasmas and slightly less so in goat, cow and buffalo plasmas. These results indicated that bovine udder strains showed lesser activity in homologous plasma. This observation was also true for three coagulase positive caprine strains.

The capacity of bovine udder strains to clot plasmas from various species of animals was in conformity with the results obtained by Klatt (1954) and Nakagawa (1958). The observations of Duthie and Lorenz (1952), that cow plasma was deficient in coagulase activator and that of rabbit and horse contained most of it, are in accordance with the findings of the present study. Saxena (1954), on the other hand, using rabbit and bovine plasmas found cent per cent coagulase positive results with bovine udder strains, the third plasma in order of susceptibility being that of equines. He also reported, goat strains, having greater plasma coagulating capacity than the strains isolated from other species. These strains showed 100% coagulase positive results in rabbit, dog, horse, bovine, sheep, goat and fowl plasmas.

The superiority of rabbit plasma for coagulase test had been confirmed by many workers (Cruickshank,1937; Chapman *et.al.* 1938; Klatt,1954 and others). Saxena (1954) found bovine plasma giving equally good results for bovine udder strains. His findings are some what contradictory to what has been reported in the present investigation. It would, therefore, be interesting to carry on further work on bovine udder strains, as his study was also limited to 15 strains only.

Some strains also differed in coagulase production, according to the place of isolation. Few strains obtained from Lucknow showed quicker results in sheep plasma contrary to the best results given in rabbit plasma by most of other strains. Goat plasma was least susceptible by these strains.

Individual strain variation was also revealed. One albus strain (M/1-102) was unable to clot rabbit plasma but gave positive result in sheep and goat plasmas.

All other plasmas except that of equine gave completely solid clots. The clots obtained in horse plasma, were soft and gelatinous. Another peculiarity with this plasma was that it gave delayed reactions in most of the cases (Table I), which supported the hypothesis of the presence of some inhibitory agent (Lominski and Roberts, 1946).

Some of the strain variations in the coagulase test might be due to anticoagulant present in some of the plasma samples (Neter, 1937) or due to lack of coagulase activator in the individual plasma samples.

The results of tube, plate and slide coagulase tests using rabbit plasma were recorded 40, 39 and 34 per cent respectively. (Table II). Assuming the index of the tube test as 100%, the results of the plate and slide tests, would be 97.5% and 85% respectively. The comparison of tube and plate test results, in this study was, therefore, slightly better than the results obtained by Penfold (1944) and comparable with that of Taylor and McDiarmid (1948). Smith (1947), on the other hand, found cent per cent results by all the three methods, excepting three strains which were unsuitable for slide test.

Williams and Harper (1946) reported the reliability of slide test to the extent of 88% which was slightly higher than the results obtained in this study. These authors recommended the use of this test for preliminary screening of the strains, the coagulase negative strains thus obtained, required retesting by tube method.

Duthie (1954) mentioned the presence of coagulase in two forms *i.e.*, bound coagulase and free coagulase. According to him, the results of slide method are given by strains having bound coagulase, which is lost in older cultures. Free coagulase, on the other hand, is retained by older cultures and gives test by the tube method. Slide test, therefore, has to be carried out when the strain is recently isolated which cannot be undertaken with strains maintained for longer periods in the laboratory. The plasma for slide test should preferrably be collected from young animals to avoid confusion of slide agglutination test due to antibodies which might be present in some of the older animals by virtue of their having accidentally, come across any Staphylococcal infection. In such cases this possibility has to be excluded by suitable tests using fibrinogen and serum from that animal.

Lack and Wailling (1954) objected tube coagulase test expressing that if growth of the organisms was not terminated during the incubation period required for clot formation, variants may destroy coagulase and hence may give wrong results, and they finally advocated plate method. Tube test apart from the objections raised by Lack and Wailling (1954) has few drawbacks. In addition to the fact that it consumes lot of time and labour, it requires meticulous care and preparation. Contamination with other organisms like Pseudomonas, *B. coli* and *B. subtilis* might give false positive results (Fisher, 1936). In tube test some strains might give flakes instead of solid clots and hence at times it becomes difficult to interpret the results.

Plate test is more reliable and less cumbersome to perform. The plates once prepared can be kept in the refrigerator and used whenever required. By applying this test to a sample, pathogenic strains can straight away be spotted even at the time of 1st isolation and this helps especially in cases where treatment is indicated.

SUMMARY AND CONCLUSIONS

1. One hundred and fifty two strains consisting of 138 strains from bovine milk samples, ten from caprine mastitis cases, one from a case of ovine abscess and three from human lesions were studied for coagulase production using plasmas from different species of animals and also by adopting different techniques of the test using rabbit plasma only.
2. Considering rabbit plasma giving 100% coagulase positive results, the reliability of plasmas from horse (97.6%), sheep (95.2%), goat and cow (88.1%) and buffalo (85.7%) was in decreasing orders, for bovine udder strains.
3. The reaction observed was quickest in rabbit plasma and delayed in horse plasma.
4. Horse plasma clots were softer and gelatinous in consistency in comparison to the hard clots of other species of animals.
5. Individual strain variations and variations in strains with regard to their place of isolation, were revealed.
6. Only three out of ten caprine strains isolated from mastitis cases, gave coagulase positive results, all the three strains being positive in rabbit plasma excepting one which showed reaction in horse plasma also.
7. The comparative tests of tube, plate and slide techniques, with 100 bovine udder strains, using rabbit plasma, showed 40, 39 and 34 positive strains respectively.
8. Out of the three techniques of coagulase test, plate method seems to be a method of choice. The merits and demerits of each method have been discussed.

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References

1. Berger, F. H. 1943 *J. Path. Bact.* **55**, 435-440.
2. Birch-hirscheld, L. 1934 *Klin. Wschr.* ,**13** 331. (Quoted by Berger 1943).
3. Blair, J. E. 1939 *Bact. Revs.* **3**, 97-146.
4. Cadness-Craves, B. Williams, R., Harper G.J. & Miles, A.A 1943 *Lancet*, **1**, 736-738.
5. Chapman, G. H., Berens, C. Nilson, E. L. & Curcio, L. 1938 *J. Bact.* **35**, 311-334.
6. Christie, R., North, E.A. & Parkin, B. J. 1946 *Aust. J. Exp. Biol. Med. Sci* **24**, 73-78.
7. Clapper, W.E. & Wood, D.C. 1954 *J. Bact.* **67**, 545-546.
8. Cowan, S.T. 1938 *J. Path. Bact.* **46**, 31-45.
9. Cruickshank. R. 1937 *J. Path. Bact.* **45**, 295-303.
10. Duthie, E. S. & Lorenz, L. L. 1952 *J. Gen. Microbiol.* **6**. 95-107.
11. Duthie, E.S. 1954 *J. Gen. Microbiol.* **10**, 427-436.
12. Field, H. I. & Smith, H. W. 1945 *J. Comp. Path.* **55**, 63-69.
13. Fisher, A. M. 1936 *Bull. Johns. Hopk. Hosp.* **59**, 415-426. (Cited by Blair, 1939).
14. Gillespie, W. A. & Alder, V.G. 1952 *J. Path. Bact.* **64**, 187-200.
15. Gorrill, R. H. 1951 *Brit. J. exp. Path.* **32**, 151-155.
16. Hallman, F. A. 1937 *Proc. Soc. Exp. Biol. Med.* **36**, 789-794.
17. Klatt, C. H. 1954 *Nord. Vet. Med.* **6**, 303-310. (Cited in Vet. Bull. 1955, 25, item 861).
18. Lack, C. H. & Wailling, D. G.1954 *J. Path. Bact.* **68**, 431-443.
19. Loeb, L. 1903-4 *J. Med. Res.* **10**, 407-417. (Cited by Cruickshank, 1937).
20. Lominski, I. & Roberts, G. B. S. 1946 *J. Path. Bact.* **8**, 187.
21. Malik, B. S. & Singh, C. M. 1959 *Proc. Nat. Acad. Sciences.* 30, 101-108.
22. Marks, J. 1952 *J. Path. Bact.* **64**, 175-186.
23. Much, H. 1908 *Biochem. Z.* **14**, 143-155. (Quoted by Blair, 1939).
24. Nakagawa, M. 1958 *Jap. J. Vet. Res.* **6**, 19-33.
25. Neter, E. 1937 *J. Bact.* **34**, 243-254.
26. Penfold, J. E. 1944 *J. Path. Bact.* **56**, 247-250.
27. Plastridge, W. N., Anderson, E.O., William, L. F. & Weirether, F. J. 1939 *Stours. Agr. Fxper. Sta. Bull.* **231**, 1-60. (Quoted by Slanetz and Bartley, 1953).
28. Reid, J. D. & Jackson, R. M. 1945 *J. Lab. Clin. Med.* **30**, 155-160.
29. Saxena, S. P. 1954 Thesis Associateship. Indian Veterinary Research Institute, Mukteswar (U.P.).

30. SELBIE, F.R. & SIMON, R. O. 1952 *Birt. J Exp. Path.* **33**, 315-326.
31. SLANETZ, L. W. & BARTLEY, C. H. 1953 *J. Infect. Dis.* **92**, 139-151.
32. SMITH, H. W. 1947 *J. Comp. Path.* **57**, 98-115.
33. TAYLOR, J. I. & McDIARMID, A. 1948 *J. Comp. Path.* **58**. 134-137.
34. WILLIAMS. R. E. O & HARPER, G. J. 1946 *Brit. J. Exp. Path.* **27**, 72-81.

STUDY OF ANATOMICAL ASPECTS OF VASCULAR SUPPLY OF THE HUMAN HEARTS POST-MORTEM*

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The seriousness of atherosclerosis and the related ischaemic heart disease can never be overemphasised. They are among the main contributors to mortality in the more developed areas. One of the most striking and potentially important facts about ischaemic heart disease is its incidence and mortality in different populations, even when allowance is made for age distribution. There exists a striking geographic and racial variation in its incidence *i.e.*, marked prepondrance in U. S. A., U. K. and Finland, and very low incidence among the Bantus in Africa. These differences could be partly explained due to inadequate basic data used for mortality statistics of the cardio-vascular diseases, or due to differences in terminology in certifying cause of death and in classification of such cases.

Coronary artery disease is closely related to atherosclerosis and any effort to evaluate the incidence and extent of former, means a valid determination of the incidence and extent of atherosclerosis, which can only be done on post-mortem studies. It is also becoming clear that atherogenesis which was formerly believed to be inevitable consequence of ageing process is not so. As a result of recent studies by Holmen *et al*[11] on human aorta removed from autopsies on individuals between 1 and 40 years of age, it has been found that atherosclerotic changes are found in much younger age groups than realised till now. This has led to a tendency to accept the presence of early lesions of atherosclerosis as "normal" for humans in statistical sense, we can never accept their presence as "normal" in an ideal sense, as long as one believes that it sets the stage for crippling or fatal clinical disorders in later years. It is therefore essential that a measure of the degree of severity of the lesions should be obtained, in a given population sample in order to establish a base line of expectancy for each age, sex and racial group in that population. The injection of coronary arteries by radio-opaque fluids and taking skiagrams is a particularly useful method of examining for foci of narrowing indicating the presence of atherosclerotic changes which may otherwise pass unnoticed. Schlesinger[20], [21] found that more than 50 per cent points of occlusion in the coronary arteries about 5 mm in length are overlooked with ordinary dissection.

Several workers[6], [27] have emphasized the influence of accessory coronary arteries on the effectiveness of coronary circulation. Brink[4] attributed the low incidence of Ischaemic Heart Disease in African Negroes to the pre-

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sence of an accessory coronary artery, the "Vessel X". Similarly Schlesinger *et al*[22] also emphasized the influence of a third coronary artery *viz.*, the Conus artery, on the clinical results of occlusion of the left descending and the right coronary arteries. Schlesinger[20,21,23] advocated the familial incidence of coronary heart disease on the basis of the inherited pattern of the coronary arteries. He[21] also described three distinctive anatomic and functional groups of coronary circulation by Injection technique *i.e.*, Group I, II, and III. The prognostic differences in the occurrence of myocardial infarcts in these three basic anatomical groups of coronary arteries suggest the importance of the study of anatomical aspects of coronary vessels in relation to their clinical significance. The incidence of coronary occlusion was high and the incidence of infarction highest in Group III hearts, with left coronary preponderance. In Group II hearts with balanced circulation, suffered least from effects of coronary arteriosclerosis. The group I hearts with right coronary preponderance is between the other two groups as regards the severity of coronary arteriosclerosis, and the infarcts produced in this group generally healed. Similarly Blumgart *et al*[3] observed that in groups I and II hearts the infarcts usually healed because of the availability of collateral circulation, whereas in Group III hearts they commonly end fatally.

Thus one purpose of the present study was to investigate the influence of these three coronary circulation patterns on the clinical manifestations of coronary artery occlusion in Indians.

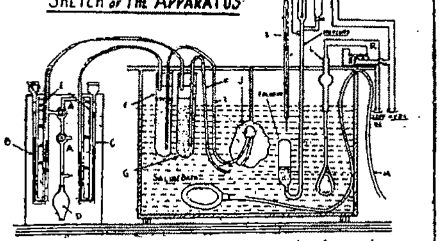
Although Schlesinger's technique[20] still remains a classic in the study of coronary circulation, it does not correlate the findings with the various myocardial bundles. Definite information on the blood supply of the myocardial bundles is needed in order to clarify the nature of muscle bundle involvement. We thus used Miale and Bledsoe's technique[16] to (*a*) demonstrate the normal and abnormal patterns of coronary circulation, (*b*) to determine accurately the blood supply of the muscle bundles, (*c*) and to support these observations by a study of the distribution of myocardial damage due to coronary narrowing or occlusion.

Finally, it was aimed to evaluate these techniques and to find out if one or both of these could be utilized as a routine post-mortem procedure to (*a*) study the predilection of atherosclerotic lesions to various situations in coronary circulation, (*b*) to find out the so-called "silent infarcts" and the possible occlusion in the minute branches of the coronary arteries and the question of coronary arterial spasm, and lastly, (*c*) to study the evidence of previous survival of infarction.

Technique :

The injection techniques aim at the study of coronary circulation by injection of various substances. Some of these substances act as corrosives, where the cardiac muscle is digested facilitating the study of the coronary

SKETCH OF THE APPARATUS



A. A THREE WAY STOPPER

B. MERCURY MANOMETER FOR LEFT CORONARY ARTERY

C. MERCURY MANOMETER FOR RIGHT CORONARY ARTERY

D. RUBBER PUMP FOR PRESSURE

E. SCALE

F. RESERVOIR FOR INJECTION MASS FOR RIGHT CORONARY ARTERY

G. RESERVOIR FOR INJECTION MASS FOR LEFT CORONARY ARTERY

H. CANNULA FOR LEFT CORONARY ARTERY

I. CANNULA FOR RIGHT CORONARY ARTERY

J. HEART

K. THERMOMETER

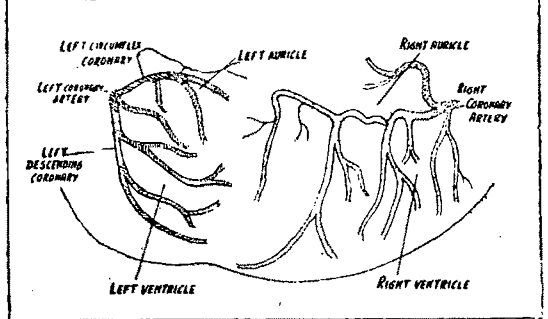
L. HEATER

M. BLOWER

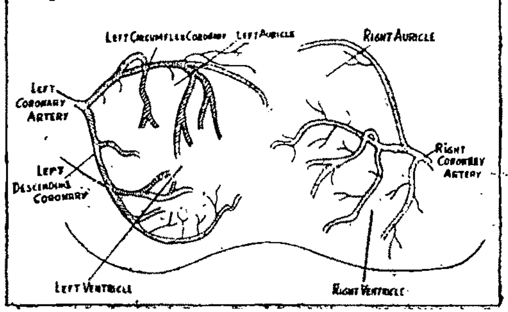
N. THERMOREGULATOR

R. ELECTRO MAGNETIC RELAY SWITCH FOR HEATER

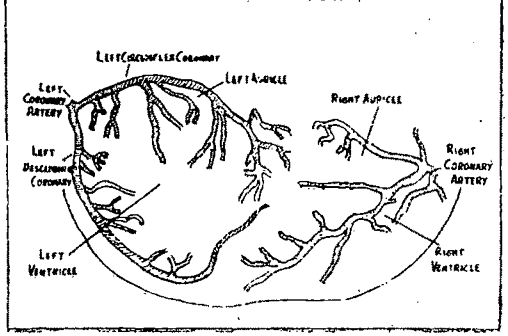
GROUP I HEART - RIGHT CORONARY PREPONDERANT TYPE



GROUP II HEART - BALANCED CIRCULATION TYPE



GROUP III HEART - LEFT CORONARY PREPONDERANT TYPE



vascular pattern, whereas others preserve the cardiac muscle enabling further histological examination.

Various substances have been used to study the pattern of coronary circulation. These are :

(1) Metallic substances like mercury[13],[18] and alloys of low melting point[12],[17].
(2) Various dyes like Saffron[29], Prussian blue[1], India Ink[34], Silver Nitrate mixed with gelatin[8], and various other ingredients.
(3) Various injection masses like plaster of paris[2], India rubber[5], Oil of Sesame[28], Shellac[9], and hot wax mixed with oil and fats and stained by Cinnabar[26], chrome yellow gelatin[25], celloidin[35], latex rubber[10], glass spheres[19] and nylon[33].
(4) Radio-active substance like salt suspension of erythrocytes labelled with radio-active phosphorus[19].
(5) Radio-opaque substances like Red lead[15], Barium sulphate[7], Lead phosphate agar[20] and various radio-opaque rubber compounds.

Techniques Employed :

The following two methods were used in the study of coronary circulation:
(1) Schlesinger's technique (modified)[24].
(2) Miale and Bledsoe's technique[16].

Schlesinger's technique (modified)[24]

The apparatus used is clearly illustrated in Fig. 1. The method essentially consists in the injection of radio-opaque lead phosphate at 44°C (pressure 150 mm of Hg) tinted blue and red for the left and right coronary arteries respectively. The injected agar mass is solidified by placing the heart in iced normal saline. The heart is then unrolled by a series of incisions, so that the coronaries are brought into one plane without cutting any of its main branches. A skiagram of the unrolled heart with the septum is taken and the coronary arteries are dissected with the aid of the skiagram. Cardiac muscle is later subjected to histological examination which is a distinct advance over the corrosive technique. There is no overlapping of the arteries on roentgenogram.

Miale and Bledsoe's technique[16] :

This is a combined injection dissection cross-section technique. It consists of the injection of radio-opaque Barium sulphate at room temperature, coloured red and blue for the right and left coronary arteries respectively. The uncut heart is X-rayed. It is then fixed in 10% formol saline for 7 days and later sliced like a loaf of bread at a distance of 1 to 1.5 cm. These cut slices are then X-rayed. Accurate outline drawings are made of the uncut heart and the slices with the aid of X-ray plates. Abnormalities are noted in the coronary arteries and the heart muscle, which are confirmed by suitably passed histological sections. The coronary arteries are further studied by dissection along with the easily visible injection mass.

Evaluation of Schlesinger's[24] *and Miale and Bledsoe's*[16] *techniques :*

Schlesinger's technique provides an excellent method for the study of coronary artery pathology. The anatomical pattern of coronary arteries can be classified into three distinctive anatomic and functional groups, the importance of which is already mentioned. This is not possible in Miale and Bledsoe's technique.

There is no overlapping for the arteries on roentgenograms in Schlesinger's technique, whereas a considerable amount of overlapping occurs in the uncut hearts studied by Miale and Bledsoe's technique thus leading to difficulty in interpretation.

The technique of unrolling the heart in Schlesinger's technique brings the entire coronary arterial tree into one plane without cutting any of their major branches, thus facilitating a thorough study of the coronary arterial tree, which is not applicable in Miale and Bledsoe's technique.

In Schlesinger's technique the limitations to the use of the lead agar injection mass are its method of preparation and viscosity. Its viscosity at 45°C compared to the blood is 3 : 1, this limits its penetration upto the limit of precapillary arterioles. On the other hand, barium sulphate mixture used in Miale and Bledsoe's technique has the advantage in that it is radily prepared from commerically available radio-opaque barium sulphate, and secondly its viscosity to blood is 1.5:1, thus enabling better penetration during injection.

Miale and Bledsoe's technique has another advantage in being a combined injection dissection cross-section technique. It provides information on the state of the coronary arteries with data referable to the various cardiac muscle bundles which can only be obtained from the study of corss-section slices. This is not possible with Schlesinger's technique, as there the relationship of the coronary disease to myocardial damage is studied in the "unrolled" heart.

Lastly, Miale and Bledsoe's technique is simple. The injection is carried out at room temperature, thus avoiding the apparatus and manipulation required with lead agar which solidifies at room temperature. This method also permits a much closer correlative study of pathological changes in the myocardium with coronary occlusion.

Broadly speaking, both the above mentioned techniques could be very usefully employed for post-mortem investigation of cases of coronary occlusion which otherwise go undetected.

RESULTS

Schlesinger's technique (modified)

80 human hearts from medico-legal cases or ward patients without any history of coronary disease were injected by the modified Schlesinger's technique. Age group of these patients ranged from 11 to 70 years. Out of the total cases studied 80 per cent were males and 20 per cent females. 19 hearts showed mild to moderate degree of atherosclerosis with narrowing or occlusion of the lumen of the vessels, resulting in the development of anastomosis between the right and left coronary arteries. Convergent type of anastomosis was observed in cases with marked narrowing of the coronary arteries as a result of atherosclerotic process, and L-L and R-L anastomosis developed in cases with mild to moderate degree of occlusion of the vessels. A few hearts showed the presence of fresh to organized thrombi. Rest of the 61-hearts were essentially normal.

The anatomic pattern of the coronary arteries were described into three distinctive anatomic groups as group I, group II and group III as shown diagramatically in Fig. 2, 3 and 4.

Group I. Heart—Right Coronary Preponderant type : The right coronary artery supplies the whole of the right ventricle plus the posterior half of the interventricular septum, along with a part of the left ventricle. In addition, the posterior descending coronary artery arises from it.

Group II Heart—Balanced Circulation type : The two ventricles receive their entire blood supply from the correspondingly named coronary artery. Right coronary supplies only the right ventricle plus the posterior half of the inter-ventricular septum, and the left coronary artery supplies the left ventricle plus the anterior part of the interventricular septum. The right coronary artery has no significant branches extending to the posterior half of the left ventricle and the circumflex coronary artery has no branches traversing the interventricular sulcus.

Group III Heart—Left Coronary Preponderant type : Here the left coronary artery supplies more than the left ventricle and the anterior part of the interventricular septum. Three degrees of cases can be recognised in this particular group.

(1) In the first degree hearts, both right coronary artery and the left circumflex coronary artery extend to the crux of the heart and both terminate in parallel posterior descending branches.

(2) In the second degree hearts the terminal branch of the left circumflex coronary artery constitute the sole posterior descending coronary artery. Here the left coronary artery supplies not only the whole of the left ventricle, but also the entire interventricular septum, both anteriorly and posteriorly.

(3) In the third degree hearts, the left coronary artery supplies blood not only to the left ventricle and the entire interventricular septum, but also to a part of the right ventricle.

In the present study Group I Heart constituted 63.75 per cent ; Group II Heart—25.00 per cent and Group III Heart—11.25 per cent. Table I gives an analysis of comparison of distribution of coronary pattern with other workers :

Table 1

Analysis of comparison of distribution of coronary pattern with other workers.

Workers	Group I in percentage	Group II in percentage	Group III in percentage
Schlesinger (1940)	48	34	18
Blumgart et al (1940)	40	40	20
Mathur and Wahi (1954)	55.2	34.3	10.5
Present study (1959)	63.75	25.00	11.25

No conus artery, vessel X, or any significant accessory artery was detected in the present study. Finally a detailed correlative study of the histological findings with the roentgenogram was carried out. None of the hearts studied showed evidence of myocardial infarction.

Mjale and Bledsoe's technique :

20 human hearts were studied by this technique. As a result of the present study it is felt that this technique could be very usefully applied to the study of myocardial infarcts which may be either asymptomatic or asymptomatic with post-infarction changes in the musculature. But as the present study did not include any cases of infarction, further evaluation of the technique is not possible.

It is seen that the septal myocardium has a constant and predictable blood supply—the anterior portion by septal branches of the left coronary artery, and the posterior portion by septal branches of the right coronary artery. The vascular pattern was found to be fairly constant at various levels. It is also observed that each muscle bundle does not possess its own blood supply but the distribution is generally regional.

Comments :

There is relatively a rapid increase in the incidence of atheroma between the earlier age groups in all parts of the world. This may point to a relationship of atherogenesis to hormonal changes of puberty. It has been observed that it takes about two decades for the fibrous plaque to be formed and for complication to develop, and it is probable that during these two decades atheroma is a reversible process[31]. Atherosclerosis is thus basically a pediatric problem.

One of the most striking and potentially important fact about coronary heart disease is its geographic pathology. The mortality rates in our country are pretty alarming and can be said to be on the increase.[30] Among the major factors that may be involved, role of diet is being investigated. Several different aspects of the diet could be considered *e.g.*, dietary cholesterol, dietary fats and their nature, lipoproteins, caloric excess, obesity, relation of diet to production of thrombosis and deterrant affect of physical exertion on the incidence of coronary heart disease[32].

Despite the vast amount of investigations actively directed towards this problem in recent years, some of the most fundamental aspects of the coronary heart disease still remain an enigma. A wide diversity of etiological factors have been considered, but as yet there is no convincing evidence for any one factor or combination of factors to the exclusion of others in naturally occurring human atherosclerosis. Precipitating factors or positive factors such as enumerated above have had a major share of investigative research done. Predisposing causes or negative factors need more concentrated studies. These may be variations in the anatomic pattern of coronary circulation, pathological changes in arterial wall, or histo-chemical and enzymatic changes in the intima of the coronary arteries, which may predispose to the deposit of phosphalipids. The present work was confined to the study of anatomic pattern of coronary circulation in Indians, and the evaluation of injection technique in such a study.

CONCLUSION

80 human hearts were studied by Schlesinger's technique (modified) and 20 by Miale and Bledsoe's technique. With Schlesinger's technique the anatomic pattern of coronary arteries could be grouped into three distinctive anatomic and functional groups. In the present study 63.75 per cent belonged to Group 1 : 25. 00 per cent to Group II; and 11.25 per cent to Group III.

Schlesinger's technique provides an excellent method for the study of coronary artery pathology with the visualization of atherosclerotic narrowing or occlusion and the demonstration of anastomosis between the coronary arteries. Miale and Bledsoe's technique was found useful to demonstrate the normal and abnormal pattern of coronary circulation and to determine accurately the blood supply of the muscle bundles. Unfortunately none of the cases studied showed evidence of infarction, thus further evaluation by a study of the distribution of myocardial damage is not possible.

While concluding one could say that injection studies of coronary arteries could be usefully employed :

(1) For the study of anatomic pattern of coronary circulation in Indians.

(2) As a routine post-mortem procedure for : (*a*) studying the predilection of atherosclerotic lesions to various situations in coronary circulation; (*b*) detection of the so-called "silent infarcts" and the possible occlusion in the minute branches of the coronary arteries *vis-a-vis* coronary arterial spasm; and (*c*) studying the evidence of previous survival of infarction.

(3) For studying the incidence of atherosclerotic disease in Indians.

(4) For studying the relationship of various manifestations in cardiac pathology to increased coronary anatomic functionalisation.

(5) To correlate studies of clinical manifestations of atherosclerosis and coronary artery occlusion with the extent and site of myocardial infarction.

REFERENCES

1. Bellerminow, A. : Cited by Whitten, H. B. : A review of technical methods of demonstrating the circulation of the blood. *Arch. Int. Med.*, **42** : 846,1928.
2. Bianche, S. : *Ibid.*
3. Blumgart, H. L., Schlesinger, M. J. & Davis, D. : Studies on the relation of the clinical manifestations of Angina pectoris, coronary thrombosis and myocardial infarction to the pathological findings. *Am. H. J.*, **19:** 1, 1940.
4. Brink, A. J. : Clinc. Proc. (South Africa). **8** : 137, 1949.
5. Frank, F. : Cited by Whitten, H. B. : *Arch. Int. Med.*, **42** : 846, 1928.
6. Grant, J. C. B. : "A method of Anatomy", Ed. 3, Williams and Wilkins Company, Baltimore.
7. Gross, L. : Cited by Sharma, G. L.[24]
8. Golubew, W. Z. : Cited by Whitten, H. B. : *Arch. Int. Med.*, **42** : 846, 1928.
9. Hoyer, H. : *Ibid.*
10. Hill, W.C.O. : Cited by Salans, A. H. and Tweed, P. : Preliminary study of coronary circulation Post-mortem. *Am. H.J.*, **33** : 477, 1947.
11. Holmen, R. L., McGill H. C. Strong, J. P. & Geer, J. C. : The Natural history of Atherosclerosis. The early Aortic lesion as seen in New Orleans in the middle of the 20th century. *Am. J. Path.*, **34** : 209, 1958.
12. Hyrtl, A. : Cited by Fredrick, A.W. & Thomas, J. D. : A history of heart and circulation, W.B. Saunders Co., Phil. & Lond., 1948.
13. Lancici, G. H. : *Ibid.*
14. Mathur, K. S., Wahi , P. N. & Pal, D. : Study of Myocardial damage by injection technique. *Agra University J. Of Res.*, Science *Vol.* **3** (2) 509, 1954.
15. Merkol : Cited by Oberhelman, H. A. & LeCount, E. R.[18].
16. Miale, J., Bledsoe, A. : Pathologic Anatomy of Coronary Heart Disease. *A.M.A. Arch. Path.*, **56** : 577, 1953.
17. Nussbaum, A. : Cited by Whitten, H. B. : *Arch. Int. Med.*, **42** : 846, 1928.
18. Oberhelman, H. A. & LeCount, E. R. : Variations in the anastomosis of the coronary arteries and their sequences. *J. A. M. A.*, **82**: 1821, 1924.

19. Prinzmetal, M., Simkin, B., Bergman, H. C., & Kruger, H.W. : Studies on the coronary circulation—II. The collateral circulation of the normal human hearts by coronary perfusion with radioactive erythrocytes and glass spheres. *Am. H. J.*, **33** : 420, 1942.
20. Schlesinger, M. J. : An injection plus dissection study of coronary artery occlusion and anastomosis. *Am. H. J.*, **15**: 528, 1938.
21. Schlesinger, M. J. : Relation of anatomic pattern to pathologic conditions of the coronary arteries. *Arch. Path.*, **30** : 403, 1940.
22. Schlesinger, M. J., Zoll., P.M. & Wessler, S. : The Conus artery : A third coronary artery. *Am. H. J.*, **38** : 823, 1949.
23. Schlesinger, M. J. : "Blood, Heart and Circulation Symposium." American association for the advancement of Science Publication. The Science Press Printing Company, Washington D. C.
24. Sharma, G. L. : Norphologic changes in coronary heart disease. *Ind. Med. Gaz.*, **84**: 3, 1949.
25. Spaltcholz, W. : Cited by Whitten, H. B. : *Arch. Int. Med.*, **42** : 846, 1928.
26. Swammerdam, J. : Cited by Fredrick, A. W., & Thomas, J. D. : A history of heart and circulation. W. B. Saunders Co., Phil. & Lond., 1948.
27. Symmers, W. : St. Clair ; *J. Anat. & Physiol.* **41** : 141, 1907.
28. Taguchi : Cited by Whitten, H. B. : *Arch. Int. Med.*, **42** : 846, 1928.
29. Viussent : *Ibid.*
30. Wahi, P. N. : Incidence of Heart Disease in India. Paper presented at the W.H.O Study Group in Washington, October,1957 (Personal Communication).
31. Wahi, P. N. : Natural history of Atherosclerosis. Paper presented at XXII : U. P. State Medical Conference at Agra. October, 1957 (Personal Communication).
32. Wahi, P. N. Atherogenesis. *Agra Med. College Jr.* **1** : 28, 1959.
33. Wegner, A. & Poindexter, C. A. : Demonstration of the coronary arteries with nylon *Am. H. J.*, **37** : 258, 1949.
34. Wearn, J. T. : Harvey lectures. 1935-40. Williams & Wilkins Co., Balimore.
35. Whitten, H. B. : Cited by Sharma, G. L.[24]

RADIATION CHARACTERISTICS AND NUCLEAR ENERGY LEVELS OF SOME PLATINUM METALS*

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Introduction

The metals platinum, palladium, irridium, rhodium, osmium, and ruthenium generally occur together in nature, and as such, are called platinum metals. Osmium, irridium, and platinum with atomic numbers 76, 77, and 78 respectively, were chosen for the present study, because the information on the radiations and the nuclear energy levels around closed shells with 82 and 126 nucleons is far from complete. Various properties of the radiations emitted from four radioactive isotopes of platinum, with atomic masses 191, 193, 195, and 197 were examined. Nuclear energy levels of platinum, with atomic masses 195 and 196 were investigated through the decay of two radioactive isotopes of gold, of mass numbers 195 and 196 respectively. Energy levels of osmium, of atomic mass 188 were established in the decay of rhenium of mass number 188.

Measurements on gamma rays were carried out with a NaI (Tl) scintillation spectrometer. A set of two such channels was used for the study of coincidences, employing a coincidence circuit with 0.2 microsecond resolving time. Beta ray measurements were carried out using anthracene crystal in the scintillation spectrometer, and also with a thin-lens type magnetic spectrometer. The radioactive isotopes were produced by bombarding stable nuclei, with slow neutrons in the Brookhaven pile. In one case, deuterons from a cyclotron were used to produce the radioactive isotope. Chemical purification was performed in each case, to remove the impurities due to metals other than the one under study.

Radiations from Four Isotopes of Platinum[1]

In most of the previous investigations on the radiations from the isotopes of platinum, natural platinum was used to produce the various activities by slow neutron bombardment. Almost all of the odd mass isotopes of platinum were produced. Three of the radionucleids so produced have approximately the same half lives. Hence, some uncertainties always remained in the proper assignments of the radiations to the proper isotope. In the present experiment, isotopically enriched and chemically pure, even mass isotopes of platinum were used as targets for producing the radioactive isotopes by slow neutron bombardment.

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* An abstract of the Ph. D. thesis submitted to the Agra University in January 1957.

RADIATOINS FROM PLATINUM 191

The radiations of Pt^{191} have been investigated previously, and as many as twenty-six gamma rays have been detected with the use of high resolution magnetic spectrometers. For the present study, Pt^{190} (isotopic abundance enriched to 0.76%) was irradiated by slow neutrons. In the scintillation spectrometer of the present experiment, it was possible to resolve only seven photopeaks. Virtually all of these peaks displayed half-widths larger than would be expected from the known resolution of the spectrometer. This observation is in agreement with the reported complexity of the gamma ray spectrum.

With the resolution available, it was nevertheless, decided to investigate insofar as was possible, the cascade relationships among the gamma rays. The presence of nine gamma rays is firmly established. Coincidence studies between the various gamma rays give a firm support to a previously proposed level scheme for the Ir^{191} nucleus. Such a coincidence study was neglected in the earlier experiments.

RADIATIONS FROM PLATINUM 193m

The radiations of the 4.3-day Pt^{193m} have been previously examined, with varying results. In the present investigation, the isotopic enrichment of Pt^{192}, the target material, had been increased to 13%. After exposure to slow neutrons in a pile, the platinum fraction was separated from gold, mercury, and irridium. In the gamma ray spectrum, three photopeaks at energies 99, 130, and 175 keV are found. The three photopeaks are interpreted as being emitted in the decay of Pt^{195m} (99 keV), Pt^{193m} (130 keV), and Pt^{191} (175 keV). Coincidences were sought between the various possible pairs of photopeaks, but none were found, consistent with the various assignments given above. The 130 keV gamma ray is heavily converted and has been classified as emitted in an M_4 transition. Thus the presence of only one gamma ray of energy 130 keV is ascribed to this isotope. In the past measurements, gamma rays of energies about 1.6 and 1.7 mev have been reported. A thorough search for any gamma rays of energies greater than 700 keV gave a negative result.

RADIATIONS FROM PLATINUM 195m

In the present investigations, sources of Pt^{195m} were obtained by irradiating Pt^{194} (isotopic enrichment 65%) with slow neutrons. The gamma rays emitted in the decay of Pt^{195m} to the ground state have been examined. This isotope has been the subject of frequent measurements in which the presence of a 31 keV to 99 keV gamma ray cascade is shown. However, no definite conclusions regarding the presence of a cross-over transition of 130 keV energy, in competition with the above mentioned cascade are available. In the latest study, its presence was not confirmed.

To shed some light on this matter, this isotope has been re-examined. Gamma-gamma coincidence study confirmed the presence of the 31 keV to 99 keV cascade. Also another cascade of 130 keV to 130 keV gamma rays is shown to be present. The presence of the 130 keV cross-over transition, in competition with the 31 keV to 99 keV gamma ray cascade is established.

From the above data, an energy level scheme for the Pt^{195} nucleus is constructed. Three levels above the ground state of Pt^{195}, at energies 99, 130, and 260 keV are suggested. Spin sequence, starting from the ground state, of p 1/2, p 3/2, f 5/2, and i 13/2 is suggested, consistent with the measurements.

RADIATIONS FROM PLATINUM 197

This isotope was produced by the bombardment of enriched Pt^{196} with slow neutrons. The isotopic enrichment of Pt^{196} was 66%. Pt^{197} thus produced, decays by negatron emission (half life of about 18 hours) to the excited states in Au^{197}. The pulse height distribution of the subsequently emitted gamma rays revealed the presence of three gamma rays, with energies of 77, 191, and 279 keV, respectively. The relative intensities of the unconverted quantum radiations are found to be, in order of ascending energy, 30, 3.9, and 1. The results of gamma-gamma conincidences established the cascade relationship of 77 and 191 keV gamma rays. The 279 keV gamma ray is found not to be in coincidence with the other two gamma rays.

On initially considering the various quantum energies, and the accuracy of the measurements, it might be concluded that the 279 keV radiation is in actuality the cross-over transition of the 77 keV to 191 keV cascade. To determine accurately, the energy of the hardest gamma ray, a careful comparison of the position in energy of its photopeak was made with that of the photopeak of the monochromatic 279 keV gamma ray of Hg^{203}. The positions were found to be identical. Precautions were taken to eliminate any possible gain shifts which might arise from differeing counting rates of the two sources by equalizing their integral counting rates. From a consideration of the channel width of the scintillation spectrometer, it was concluded that the energies of the two gamma rays may differ at most by 3 keV. This fact combined with the coincidence data, and the previously accurately determined values of the two softer gamma rays, led to the conclusion that the 279 keV transition could not be emitted in the cross-over transition.

A thorough search for gamma rays of energies greater than 500 keV gave a negative result. From the background counting rate of the spectrometer, it was estimated that any gamma rays present with a quantum energy of about 550 keV could be emitted only with a probability of less than 10^{-4} per disintegration.

The K shell conversion coefficient of the 191 keV gamma ray has been evaluated from the coincidence spectrum of the quantum radiations with the 77 keV gamma ray, and is found to be 2.5. If 191 keV transition was a pure M_1, then the theoretically expected value of K shell conversion coefficient is about 1. If it were a mixture of E_2 and M_1, then the theoretical value would still be smaller. However, it was concluded that the 191 keV transition was M_1 in nature.

Anthracene crystal was used to detect the beta ray spectrum. Beta-gamma concidence experiment revealed the presence of three beta ray groups, with maximum energies of 468, 479, and 670 keV respectively. In the ascending order of energies, the relative intensities are found to be 0.9, 10.6, and 88.5 per cent, with log ft values of 7.80, 6.88, and 6.36 respectively. The beta ray transition from the ground state of Pt^{197} to the ground state of Au^{197} was not detected.

From the above measurements an energy level scheme is proposed for the Au^{197} nucleus. Three excited states above the ground state, at energies 77, 268, and 279 keV are established. Starting from the ground state, the suggested spin sequence is 3/2, 1/2, 3/2, and 5/2, all with even parity.

As shown above, the measured K shell conversion coefficient for the 191 keV gamma ray is higher than the theoretically expected value, assuming that the 191 keV transition is pure M_1. To explain this higher value, it has recently been proposed[2] that the spin of the 268 keV level could be 1/2 instead of 3/2 as proposed above. In that case the 191 keV transition could be a mixture of M_1 and E_0 transitions, which would give a higher theoretical value for the K shell conversion coefficient, in agreement with the measured value. It would be very important to measure this conversion coefficient by other methods to verify this explanation.

ENERGY LEVELS OF TWO ISOTOPES OF PLATINUM[3]

Naturally occurring platinum was irradiated by deuterons in the cyclotron at the University of Pittsburg. The radioactive isotopes of gold thus produced were chemically separated from irridium, mercury, and platinum. The gamma ray spectrum was taken after two weeks following the cessation of irradiation. Photopeaks at energies 65, 158, 350, and 425 keV are seen. The 158 keV gamma ray was identified by its decay period as being emitted in the disintegration of Au^{199} (half life 3.1 days), and the 350 keV and 425 keV quanta could similarly be assigned to Au^{196} (half life 5.6 days). The x-ray energy of 65 keV is characteristic of the region of noble metals. Au^{196} decays to Pt^{196} by orbital electron capture and the subsequent emission of a 330 keV to 358 keV gamma ray cascade. Since no interference from other gamma rays is expected, angular correlation experiment between the 330 keV and 358 keV gamma rays was immediately performed. The results are given in the next few paragraphs. Then the source was kept aside for three months. In this time Au^{196} and Au^{199} decayed down considerably and were left in negligible amounts. When the gamma ray spectrum was again taken, it showed the presence of gamma rays emitted in the disintegration of Au^{195} alone (half life 185 days). The results of the measurements on these gamma rays is given below.

SPINS OF LEVELS IN PLATINUM 196

Au^{196} decays to Pt^{196} by orbital electron capture and the subsequent emission of the 330 keV to 358 keV gamma ray cascade. It also decays by negatron emission to Hg^{196} followed by the gamma ray emission of energy 425 keV. The angular correlation function of the 330 keV to 358 keV gamma ray cascade has been measured. The source, prepared in the manner described above, was in the form of metallic gold contained in a carbon cylinder. Pulse height selection was employed in either channel, each being set at the photopeak appearing at about 350 keV. The distance of the source from the face of either crystal was 13cm, and the half-angle of the detecting system was 7.5 degrees. Measurements were performed at five different angles, the moving channel being placed at intervals of 22.5 degrees between the angles of 90 and 180 degrees. Coincidences were accumulated at each angle for a period of five minutes at a time. This range of settings was traversed repeatedly so that any decay correction was eliminated. Approximately 10,000 coincidences were obtained at each angle.

The results of the measurement suggest the spin of zero for the ground state, and of two for both the excited levels at energies 358, and 688 keV. All the three levels have even parity. The gamma ray transition between the second and the first excited states is found to be a mixture of 96.7 per cent E_2 and 3.3 per cent M_1. The mixing ratio was found to be positive.

ENERGY LEVELS OF PLATINUM 195

The radiations from Au^{195} have been examined in the past in magnetic spectrometers and coincident geiger counter arrangements. Two gamma rays of energies 31 and 99 keV were found to be in cascade in all of these measurements. The data regarding the presence of 130 keV cross-over transition in competition with 31 keV to 99 keV gamma ray cascade have been inconclusive.

The source of Au^{195} used in the present experiment was prepared in the manner described above. The pulse-height distribution of the gamma rays from Au^{195} revealed the presence of three gamma rays of energies 31, 99, and 130 keV, with unconverted quantum intensities of 1, 12, and 2, respectively.

Absorption measurements on each of the gamma ray were carried out using copper as an absorber. Half-value thicknesses for different gamma rays were found to be 113, 69, and 3 mils of copper, which correspond to gamma rays of energies 130, 99, and 31 keV, respectively. Thus it is confirmed that the 130 keV transition does not arise due to simultaneous detection of the other two gamma rays. Gamma-gamma coincidence measurements confirmed the cascade relationship of 31 keV and 99 keV gamma rays. 130 keV gamma ray was not found to be in coincidence with the other two gamma rays.

From these data, an energy level scheme for Pt^{195} nucleus is proposed. Two levels above the ground state of Pt^{195} at energies 99, and 130 keV are suggested. Starting from the ground state the suggested spin sequence is p 1/2, p 3/2, and f 5/2. This level scheme is in agreement with the one arrived at in the decay of Pt^{195m}, already described.

ENERGY LEVELS OF OSMIUM 188[4]

Isotopically enriched (98.22%) Re^{187} was bombarded by slow neutrons in the Brookhaven pile, for a period of 24 hours, to produce Re^{188}. Several samples of 25 mg each were employed. In each case, the measurements were commenced within 12 hours after the target material was removed from the pile, and were continued for about three days thereafter.

Re^{188} decays by negatron emission (half life 18 hours) to the levels in Os^{188}, with the subsequent emission of gamma rays. From the study of the gamma ray spectrum, the gamma rays listed in Table 1 were detected. Their relative unconverted quantum intensities are also given in the table. In the earlier studies on this isotope, natural rhenium metal was used to produce the activities. Only seven gamma rays were detected in the past.

Table 1

Unconverted quantum intensities

Gamma-ray energy in keV	Relative intensity
155	6.30
478	0.67
633	0.98
660	0.02
828	0.35
931	0.43
1132	0.08
1307	0.14
1610	0.13
1780	0.06
1805	0.03
1960	0.03

Extensive gamma-gamma coincidence measurements were performed to find out the relationships between various gamma rays.

Beta rays have been examined in a thin-lens type magnetic spectrometer, of resolution of about two per cent. The percentages of the two major beta ray groups with maximum energies 2150 and 2000 keV are found to be 79 and 20, respectively. About one per cent of the beta ray disintegrations lead to higher levels in Os^{188}. The log ft values of the three beta ray components, in the descending order of energy, are estimated to be 8.1, 8.6, and 9.4, respectively. They indicate that all of the beta ray spectra are of first forbidden degree and thus involve a parity change in the transitions.

The internal conversion electron spectrum of the gamma rays show the presence of K, L, and M+N conversion lines of only one gamma ray, of energy 155 keV. The K/L ratio for the 155 keV gamma ray is estimated to be 0.70 ± 0.05. A search for the conversion lines of other gamma rays, and particularly for the 478 keV gamma ray, gave a negative result.

The K shell conversion coefficient of the 155 keV gamma ray has been measured by two methods, employing scintilation spectrometer and magnetic spectrometer. The two values thus obtained are $0{\cdot}29 \pm 0.03$ and 0.37 ± 0.05. The theoretical values for M_1, E_1., and E_2 are 1.73, 0.11, and 0.33, respectively. The measured value thus favours an E_2 character for the 155 keV gamma ray. The measured K/L ratio is also in agreement with the expected values of 0.7 for an E_2 character of the 155 keV transition.

To find the spins of the first two excited states of Os^{188}, an angular correlation function between the 155 keV and 478 keV gamma rays is measured. The measurement suggests a spin zero to the ground state and a spin of two to the first and second excited states, all with even parity. The measurements also showed that the 478 keV transition is a mixture of 99.5% of E_2 and 0.5% of M_1 transitions.

From the above data, an energy level scheme is constructed for the Os^{188} nucleus. Eight excited levels above the ground state are suggested at energies 155, 633, 1086, 1293, 1461, 1765, 1940, and 1960 keV. The spins of the ground states and of the first two excited states are zero and two respectively, all having even parity.

REFERENCES

For details and other references to earlier work, see

1. Radiations from Four Radioactive Isotopes of Platinum, V. R. Potnis, C. E. Mandeville, and J. S. Burlew, *Phys. Rev.* **101**, 753-758, 1956.
2, Electric Monopole Transitions in Nuclei with Odd Mass Numbers, L. K. Peker and L. A. Sliv, J. Exptl. *Theoret. Phys.*, (*U. S. S. R.*) **32**, 621-622, 1957.
3. Radiation from Two Radioactive Isotopes of gold, V. R. Potnis, *Indian J. of Physics* Vol, **30**, 375-383, 1956.

Nuclear Energy Levels of Os^{188}, V. R. Potnis, *Phys, Rev.* **104**, 722-727, 1955.

Angular correlation in Os^{188}, V. R. Potnis, V. S. Dubey, and C. E. Mandeville *Phys, Rev.* **102**, 459-461, 1956.

REACTION MECHANISMS FOR THE CONDENSATION OF CHALCONES WITH FLAVANONES AND ACETOPHENONE

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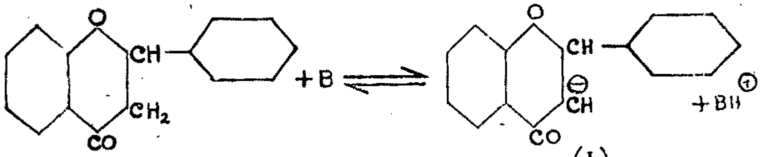
Chalcones frequently condense with compounds containing active methylene group in an open chain, such as acetoacetic ester[1] and desoxybenzoin[1],[2]; homocyclic ring, like cyclohexanone; or in a heterocyclic ring as in a flavanone[3].

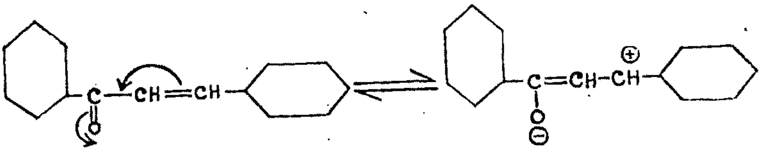
For the discussion of reaction mechanism involved in the condensation of chalcone with flavanone, in presence of alkali, the formation of carbanion is assumed. It is postulated that a flavanone furnishes carbanion with the expulsion of a proton from its keto methylene group under the influence of strong alkali present :



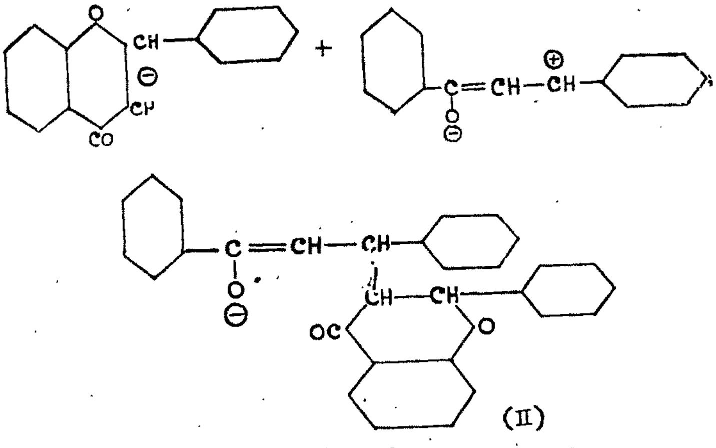
(I)

(B=Basic Catalyst)

The carbanion thus produced would induce the electromeric change in the keto ethylene group present in the chalcone molecule :



The anion I then joins the positive carbon forming the anion II :



(II)

Addition of cation to anion II produces the electrically neutral molecule

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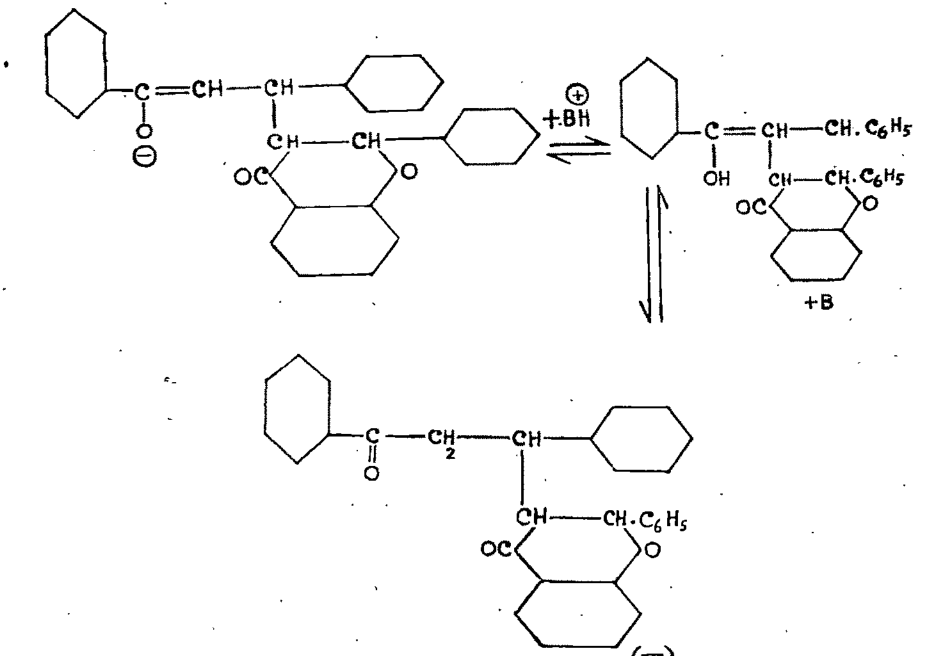
III, *i.e.*, the basic catalyst is regenerated and the condensation product of chalcone and flavanone results :



(III)

A nitro group in the chalcone molecule lowers the electronic density on the keto oxygen and hence it is expected to interfere in the carbanion formation, with the net result that nitrochalcones should fail to undergo the above type of condensation. This conclusion is actually borne out by the experiments of Kaplash et al[3]. An analogous effect is obviously to be expected with other substituent groups which likewise hinder the carbanion formation.

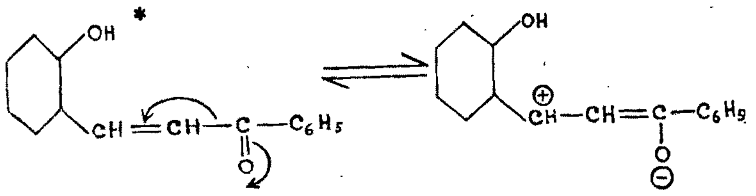
CONDENSATION OF CHALCONES WITH ACETOPHENONE

It may plausibly be assumed that the first step in the condensation of a substituted chalcone with acetophenone is the conversion of the carbonyl compound, acetophenone, into its conjugate base (carbanion) under the influence of a strong base, whereby a proton is split off from the α—carbon, according to the scheme :

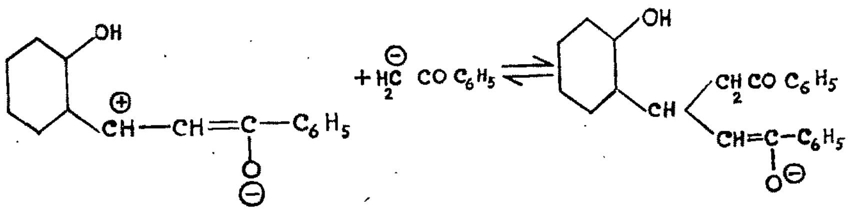
$$CH_3COC_6H_5+B \rightleftharpoons \overset{(-)}{H_2}CCOC_6H_5+\overset{(+)}{BH}$$

under the influence of the approach of the carbanion the electromeric effect is induced in the conjugated system; $-C=C-C=O$, present in chalcone. Taking 2-hydroxychalcone as an example

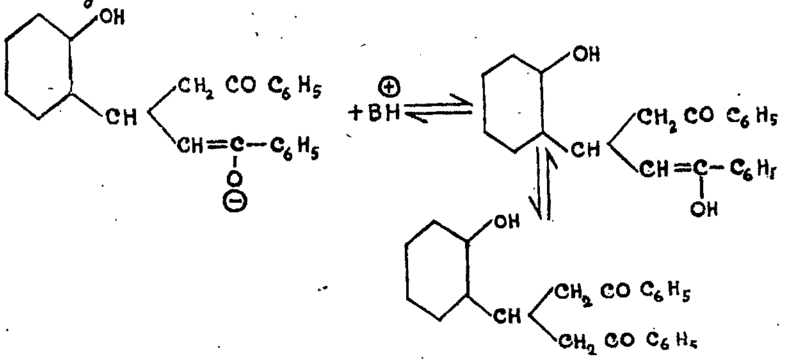
We have :



The nucleophilic carbanion then combines with the positive carbon atom of 2-hydroxychalcone :



Finally we have :-



All the above equations are reversible. The driving force in the forward direction is the formation of a new C—C bond.

From the foregoing it is apparent that the extent of condensation will be determined by the acetophenone ion concentration, which in turn is proportional to the hydroxyl ion concentration. It follows, therefore, that the presence of high concentration of hydroxyl ions should provide conditions favourable for the condensation of 2-hydroxychalcone with acetophenone. This conclusion has been justified by the observation of Kostanecki and Cornelson[4] that the amount of ortho hydroxybenzylidenediacetophenone, formed in the condensation of salicylaldehyde with acetophenone, increases with the increase in concentration of alkali used. In this condensation it is assumed that 2-hydroxychalcone is the primary product, which subsequently condenses with the unreacted acetophenone in the manner cited.

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* In presense of alkali the phenolic OH of the above noted compounds will be converted into its corresponding salt, which will, however, get regenerated on acidification of the condensation product.

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LITERATURE CITED

(1) Knoevenagel. E., *Annalen*, **281**, 25-126 (1894)
(2) Hill, D. W., *J. Chem. Soc.*, 1115-8 (1935).
(3) Kaplash, B. N., R. C. Shah, and T. S. Wheeler, *J. Indian Chem. Soc.* **19**. 117-20 (1942).
(4) Kostanecki, S. v. and A. Cornelson, *Ber.*, **29**, 240-4 (1896)

FURTHER STUDIES ON B. R. C. TEOSINTE X MAIZE HYBRIDS

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Harshberger (1896) produced first fertile hybrids between maize and teosinte. Several authors have since then described the cytology and inheritance of these hybrids involving maize and various races of teosinte. This work has been well reviewed, among others, by Mangelsdorf (1947) and Randolph (1955, 1959). Singh and Paliwal (1960) have described a luxuriant form of teosinte called by them as B. R. C. teosinte. On the basis of (a) mean number of tillers per plant, (b) mean number of days to anthesis and (c) the pairing of chromosomes at meiosis in maize x B.R.C. teosinte hybrids, Singh and Paliwal (1960) conclude that B. R. C. teosinte probably falls in the group of Guatemalan teosinte. They further report that B. R. C. teosinte x maize hybrids sown in the month of February and blooming in June show the development of "Bulbil" like structures on the tassel. The crop grown in rains, however, shows no such abnormality. Most of the maize x teosinte crosses described in the literature have been made with normal male fertile maize as one of the parents. In 1958 the senior author made the crosses between a male sterile maize and B. R. C. teosinte. In the present paper the cytology and the condition of pollen of F1 hybrids of this cross along with further observations on the development of "Bulbil" like structures have been described.

Material and Methods

A male sterile form of maize obtained from U. S. A. through Mr. W. R. Schoonover was used as the female parent. The crossed seeds were sown early in February, 1959 and the observations presented in this paper were made on this population which bloomed in May-June. The pollen fertility was examined by mounting the mature pollen grains in acetocarmine or a mixture of iodine with lactic acid. For meiotic studies anthers fixed in Carnoy's fluid (6 Abs. alcohol : 3 Chloroform : 1 Acetic acid with Ferric acetate) were squashed in acetocarmine.

Observations

Male Sterility :

The F1 progeny of male sterile maize x B. R. C. teosinte was highly variable as regards to several morphological characters. The plants were either more maize like or more teosinte like particularly in respect to number of tillers per plant, number of secondary branches and the character of male and female inflorescences. On the basis of the development of tassel and the fertility of pollen these Fl hybrids have been classified in Table 1.

Table 1

S.No.	Frequency of Plants	Fertility of Male Flowers	
1.	19	Plants without any tassel or with only a barren tassel having few weakly developed spikelets. Plants practically female.	65 Male sterile Plants
2.	46	Tassel morphologically normal but producing practically no viable pollen. Pollen fertility lower than 10%. Male sterile.	
3.	7	Plants with more than 50% pollen fertility.	22 Male fertile plants.
4.	15	Plants with 80—100% pollen fertility.	

One interesting thing is revealed here. The male sterility in maize is controlled by cytoplasm, or genes, or cytoplasm-genome reaction (see Jones, 1956). When these male sterile forms of maize are crossed with other varieties of maize having pollen fertility restorer gene, the progeny shows male sterile and male fertile plants in varying proportions. It is interesting that the result of crossing male sterile maize with teosinte is similar in respect to the restoration of pollen fertility in the hybrid progeny.

Cytology :

Out of 46 male sterile plants with apparently normal tassel, meiosis was studied in 19 plants. Seven of these hybrids showed regularly 10 pairs of chromosomes at diakinesis and metaphase I (Figs. 1, 2) and meiosis proceeded normally till the formation of microspore tetrads. Later on the microspores got shrivelled and degenerated. The remaining 12 plants showed irregularities in the form of univalents at diakinesis and metaphase I (Figs. 3, 4, 5, 6). The number of univalents varied from 2—9 in a single microspore mother cell. In one plant out of 36 cells scored, 6 showed the presence of a trivalent while 3 other cells possessed as many as 3 trivalents each. Out of these 12 plants showing irregular meiosis, the pairing configurations were scored in 6 plants and the results are presented in Table 2.

Table 2

S. No. of Plant	Pairing Behaviour at	
	Diakinesis	Metaphase I
101	9·9 II+·2 I	10 II
140	9·7 II+·6 I	—
157	·78 III+5·7 II+6·25 I	5·6 II+8·8 I
166	——	9·4 II+1·2 I
177	9·2 II+1·6 I	9·4 II+1·2 I
208	9·2 II+1·6 I	9·8 II+·4 I

Usually the univalents do not arrange themselves at the equator in the metaphase plate, instead they take up a precocious peripheral position. However, these univalents are generally included in the daughter nuclei at first telophase. The distribution of chromosomes at anaphase I varies in these plants with irregular meiosis. Though most of the cells show 10-10 distribution, 12-8 and 11-9 distribution is observed quite frequently.

The second division is mostly normal and several healthy tetrads of microspores are formed. The microspores, however, degenerate soon after separation. It is, therefore, clear that irregularity in meiosis is not directly responsible for sterility of pollen grains in these hybrids. In both kinds of plants, showing regular as well as irregular meiosis, the pollen mitosis is upset.

It may be added that meiosis in hybrids classified here as fertile, also follows the same pattern as described for male-sterile hybrids. Thus some of the fertile hybrids show quite regular pairing while others show the same kinds of irregularities as described for sterile hybrids with irregular meiosis. No trivalents were, however, observed in the male fertile plants. The microspores continue further development and produce numerous viable pollen grains.

DEVELOPMENT OF BULBILS

As already reported by Singh and Paliwal (1960) the B. R. C. teosinte x maize hybrids sown early in February and blooming in May, quite frequently show a metamorphosis of the tassel into a specialized bulbil like structure. They also report that this change over of the tassel to vegetative condition starts after the complete development of male spikelets.

This population of male sterile maize x B. R. C. teosinte hybrids consisted of 214 plants. Of these hybrids only 6 plants, which were not at all morphologically different from other plants*, showed the metamorphosis of tassel into vegetative structures or bulbils. These plants which bloom comparatively late, produce healthy spikelets which look quite normal in earlier stages of development and the anther smears from these spikelets also show a normal development of microspores. In some spikelets even the stamens protrude out of the florets and dehisce before the onset of vegetative proliferation of the tassel (Fig. 7). In this respect too the present anomaly differs from that described by Reeves and Stansel (1940) in maize where the abnormal plants produce no normal tassels at all. Rogers (1950), describing a similar abnormality in the backcross progeny (Chalco teosinte x maize) x Chalco teosinte, writes, (P. 528)"................. this condition is characterized by the development of vegetative rather than floral organs in the spikelet". His figure 12 is, however, quite comparable with our Fig. 8 where a tassel showing the vegetative development also bears a few normal spikes showing no transformation into vegetative structures. Fig. 9 shows a well developed tassel with the florets on the spikes undergoing metamorphosis into vegetative structures. The tassel in these maize x teosinte hybrids may or may not have a central spike depending upon whether the hybrid is more maize like or teosinte like. In the former case the vegetative proliferation first starts on the central spike and continues to lateral spikes (Fig. 9). In such tassels which do not have any defined central spike, the vegetative growth may start on any lateral spike. The entire inflorescence does not necessarily get affected and some normal looking spikes may be observed when big leafy structures have developed on most of the other spikes of a tassel.

The first noticeable change in this metamorphosis is the elongation of the glumes and lemma of each floret (Fig. 9). The glumes grow to about four times their normal length and become quite hard and brown. Both lemma belonging to two florets of each spikelet, also start elongating and soon become big and leafy. They, however, do not show any differentiation into a leaf sheath and leaf blade. In some of the spikelets growth ceases at this stage while in others it continues through the development of a vegetative bud, which grows into a branch. Thus several branches arise on each spike and the whole tassel becomes jammed up with branches developing laterally and upward (Figs. 10, 11, 12). Adventitious roots arise at the base of each branch which thus becomes theoretically an independent plant developing in place of the original spikelet.

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* In maize the plants showing vegetative tassels, however, grow twice as tall as the normal ones (Reeves & Stansel, 1940).

Some of these tassel-branches remain vegetative and stop growing after some time. But in others reproductive organs appear in the axil of each of the 4—6 leaves present on a branch. It is, therefore, very interesting to record that these abnormal tassels after showing vegetative proliferation for some time, soon become reproductive producing secondary floral organs (Figs. 11, 12 & 13). Collins (1909), Collins & Kempton (1916), Reeves & Stansel (1940) and Rogers (1950) all consider these abnormal tassels to turn completely into vegetative structures and none of them has described the formation of reproductive organs on these vegetative tassels.

The structure of the tassel branches bearing secondary inflorescences has been represented with the help of diagrams A, B & C. The glumes of the original spikelet are seen here as the first two structures at the base of the branch. Immediately above the glumes are two lemma, which inspite of much elongation, retain their typical shape. In the axil of each lemma is a palet along with the anthers representing the male flower (Diags. B & C). Above the lemma several new leaves arise alternately on a rachis which in later stages become fairly elongated. These leaves are quite similar to normal leaves with characteristic leaf sheath, blade and a distinct ligule. In the axil of each of the first two or three leaves a male flower is found which consists of three well developed or two well developed and one abortive anther enveloped by a palet. In the axil of each of the remaining leaves is enclosed a small female inflorescence covered under a whorl of shucks. These female inflorescences or cobs which bear spikelets in two rows have several characters intermediate between the maize and teosinte cobs. There may be 2-3 such female inflorescences on each branch (Fig. 13 & Diag. C.) The uppermost leaf on each branch encloses another terminal inflorescence which, however, resembles a typical female inflorescence of teosinte (Fig. 14 & Diag. C). It is not enclosed in any shucks and as the uppermost leaf expands the terminal cob stands uncovered at the tip of the branch (Figs. 11 & 14). The grains on this terminal cob are arranged in a single file exactly as in teosinte. In a few cases, however, the terminal cob had a flattened and a zigzag rachis which thus differs slightly from the teosinte cob.

In later stages of development these branches become considerably elongated and show clear nodes and internodes with one inflorescence present in the leaf axil at each node. Each branch, which has developed from the position originally occupied by a male spikelet on the tassel, thus finally produces three different kinds of inflorescences : (1) Male flowers in the axil of first 2—3 leaves, (2) Female inflorescences or cobs of hybrid nature in the axil of next 2—3 leaves and (3) a terminal cob resembling a teosinte female inflorescence. The significance of this situation is discussed later on in the end.

CULTURE EXPERIMENTS

Singh & Paliwal (1960) reported that the tassel bulbils on maize x teosinte plants develop several adventitious roots at the base but they never observed these bulbils to get detached from the parent plant and establish as independent plants in nature. However, when artificially detached and planted in soil these bulbils developed into independent plants (Singh and Paliwal, 1960). We planted the individual branches from a bulbil at the following stages of development in containers with Knopp's solution :

(A) The spikelet showing an enlargement of glumes only.

(B) Spikelet developed into a miniature branch with glumes and lemma considerably enlarged.

(C) Spikelet which had grown into a well developed branch with axillary inflorescences.

The spikelets at stage 'A' die within a couple of days of their removal from the mother plant. The branches removed at stages 'B' and 'C' however, continue to grow and soon establish as independent plants (Fig. 15). Similarly when planted in soil these branches easily establish as independent plants and produce new inflorescences (Fig. 16). In both cases silks appear from the cobs present in the axils of the leaves and when artificially pollinated they even produce grains.

DISCUSSION

The Fl hybrids between *Zea mays* x *B. R. C. teosinte* show several irregularities at meiosis including unpaired chromosomes (univalents), heteromorphic pairs and sometimes also trivalents. This lends support to the view already expressed by Singh and Paliwal (1960) that B. R. C. teosinte falls in the group of Guatemalan teosinte.

Another fact that accrues from the present experiment is the capacity of B. R. C. teosinte genome to restore at least in part the pollen fertility in the male sterile maize. This lends support to the view expressed by Reeves & Mangelsdorf (1942) that teosinte (*Euchlaena mexicana Schrad*) should be regarded as a species of *Zea* (*Zea mexicana*).

Detailed observations on the development of bulbils from the tassel in maize x B. R. C. teosinte hybrids have produced some very interesting results. It is quite significant that the development of bulbils has been observed only in plants which were sown early in February and bloomed in May and June (see also Singh and Paliwal, 1960). Normally in North Indian conditions maize and so teosinte is sown in June; maize blooming in August-September, and teosinte in October-November. Maize x teosinte hybrid seeds take 4-5 days for germination in soil in June. In February the time required for germination under optimum moisture conditions was 20 days. The growth of the seedlings in February was slow, the overall stature of the plants remained small as compared to the plants grown in rainy season. Also finally the winter sown plants started flowering in a comparatively much shorter time (80 days) than the plants grown in rainy season. All these points appear to suggest that the development of tassels into bulbil like structures in the winter sown crop is somehow associated with the abnormal environmental conditions to which the plant is subjected. It might be either the cold temperatures to which the seeds and the seedlings are exposed in earlier stages of development or it might as well be the higher temperature and the different photoperiod which the inflorescence experiences in May and June (see also Singh and Paliwal, 1960).

Reeves and Stansel (1940) commenting upon the development of vegetative tassels in maize write, (P. 20), "........................The conditions under which the phenomenon occurs offer a slight suggestion that it may be related to Yarovization, since it seems to occur when the seeds remain in the soil in certain amount of moisture for a considerable period before the sprouts emerge. If such a relationship is real, perhaps Yarovization is a physiological process that is necessary for the expression of this anomaly." The spring season of this year had a very low rainfall. Reeves and Stansel (1940), therefore, think that the seeds, which are placed under low moisture conditions of the soil, are subjected to a phenomenon comparable with Yarovization (vernalization) and this is responsible for the abnormality. It may be added here that in our crop the moisture content was not a variable factor because the seeds were germinated in well watered pots and the young seedlings were transplanted to the plots which were also well watered as per requirement of the plants. We, therefore, think that in our plants either the low temperature in earlier stages of development or high temperature at the time of blooming may be responsible for this metamorphosis of tassel into bulbils. We are planning experiments to control the two factors and find out which of them, if at all, is responsible for vegetative proliferation of the tassel.

In our material the metamorphosis of the male spikelets on the tassel into vegetative structures started only after complete development of the stamens, as also reported by Singh and Paliwal (1960). The development of vegetative structures on the tassel, therefore, starts after the tassel (and so the plant) has completed (at least in part) the reproductive phase of development. The vegetative phase is, however, very short and soon culminates in the development of secondary inflorescences in the leaf axils of the tassel branches forming the bulbil. None of the previous observers, who have described the bulbils in maize, teosinte, or maize x teosinte hybrids have reported the presence of reproductive organs on these bulbils. In our material the tassels after a very short period of vegetative proliferation into bulbils, revert back to the reproductive phase and male or female flowers are produced in the axil of every leaf on most of the branches forming the bulbil.

Further the presence of two different types of female inflorescences or cobs differing in the structure and type of grains, on a branch of the bulbil in several cases, creates another peculiar situation. There are a few cases on record where two different types of grains have been reported from the same inflorescence. As early as 1633, Jhonson (see Zirkle, 1951) reported a grain of oat in an ear of wheat and Worm in 1655 (see Zirkle, 1951), a grain of rye in the ear of barley. Lysenko (1950) has reported several cases of the presence of grains of two different species and also two different genera on the same ear, for example, presence of soft wheat grains (*Triticum vulgare*, $2n=42$) in the spikes of durum wheat (*T. durum*, $2n=28$), rye grains (*Secale cereale*) in the spikes of wheat and so on. Lysenko (1950) holds that a change in the environment can bring about the conversion of wheat into rye, barley and oats, and this is how under the influence of environment species may arise *de-novo* by a quick step. Western geneticists have not taken these reports seriously. Maheshwari (1952), however, has written a very interesting note on "Lysenko's latest discovery" and considering if there is some truth in these reports, he has provided a theoretical explanation for this so called "Conversion of wheat into rye, barley and oats". He thinks that if some of the wheat flowers become pollinated with rye pollen and the male gamete in some cases reaches the embryo sac and "develops 'androgenetically' inside the embryo sac, seed coat and pericarp of wheat....................the offspring would be a haploid rye, but if chromosome doubling took place at some stage in embryogeny the mature grain would produce a normal diploid rye plant. The so called 'conversion' of wheat into barley or oats could also be understood as occuring in the same manner". In our opinion this provides a very plausible explanation for the origin of a rye, barley or an oat plant from the seeds obtained from a spike of wheat. But the question remains as to what would be the appearance of the grain which belongs to wheat spike and in which a male gamete of rye has developed androgenetically. In our opinion the grain in its outer appearance would look like wheat though on sowing it might give rise to a rye plant. Therefore, this view does not explain the presence of rye grains in wheat spikes and similar other cases.

The present case of the occurrence of teosinte and hybrid maize grains on one branch of the same plant differs from the cases described by Lysenko in several respects. (1) The plants in this population were hybrid between maize x teosinte. (2) The two kinds of grains were never observed on normal inflorescences but were observed only on the secondary inflorescences produced on bulbils on a few plants which could be considered as abnormal. (3) The two kinds of grains were produced on separate inflorescences though on the same branch. (4) Both maize and teosinte have the same chromosome number and are quite cross fertile. There is evidence of a lot of similarity in their genomes. (5) The two kinds of flowers producing two types of grains could be easily identified from each other even in pre-fertilization stages.

One possible explanation may be that this 'segregation of inflorescences' is brought about by some sort of somatic segregation of genes which occurs during the development of inflorescences on the bulbil and this might result in the production of two different kinds of female inflorescences, each with a different kind of grain, on the same branch. We, however, have no cytological or genetical evidence to support this. Also probably somatic segregation can not be expected to occur so regularly as to produce two kinds of grains on several branches of the bulbil.

This phenomenon could be brought about by a particular type of gene action which has a "norm of reaction quite susceptible to environmental interference" (c. f. Goldschmidt, 1955), and by a differential activity of a gene or a group of genes at different stages of development or in different parts of the organism (c. f. Waddington, 1955). This has been clearly evidenced cytologically by the differential activity of certain loci in the polytene chromosomes of the fly *Rhynchosciara* (Pavan, 1958). In plants the recent report of the structural differentiation of the chromosomes in different tissues in *Ornithogalum virens* by Lima-de-Faria et. al. (1958) is also pertinent in this respect and may throw light on the subject.

SUMMARY

When B. R. C. teosinte is used as the pollen parent in the cross with male sterile maize, the Fl progeny consists of both male sterile and male fertile plants. Some of these hybrids show regular meiosis while others show some irregularities in the form of univalents and heteromorphic pairs and sometimes trivalents.

In a population consisting of 214 maize x teosinte hybrid plants, six showed the metamorphosis of tassel into bulbil like structures. These bulbils, after undergoing vegetative development for some time, revert back to the reproductive phase. Details of the development of bulbils and the production of secondary inflorescences on the branches of the bulbil have been described. Each branch of the bulbil when artificially detached and planted in nutrient solution or soil develops into an independent plant and produces secondary inflorescences. On each branch of the bulbil three kinds of inflorescences are produced. In the axil of lower leaves only male flowers are produced. In the middle region axillary female inflorescences or cobs enclosed in shucks resembling maize x teosinte hybrid cobs are produced. The terminal inflorescence on each branch is a typical teosinte female inflorescence but is not enclosed in shucks. The significance of the presence of two different kinds of inflorescences or cobs each with different type of grains on branches of bulbil is discussed.

ACKNOWLEDGMENTS

We are indebted to Prof. Bahadur Singh for providing the material of teosinte used in this work, for valuable suggestions and for going through the manuscript. Our thanks are also due to Dr. R. K. Singh for providing the facilities of research and encouragement. The senior author is also thankful to Government of India, for providing the Senior Research Training Scholarship enabling him to carry out this work.

BIBLIOGRAPHY

1. Collins, G. N. (1900) Apogamy in the maize plant. *Misc. Papers U. S. Nat. Herb.* **12** ; 453—455.
2. Collins, G. N. & Kempton, J. H. (1916) Patrogenesis. *Jour. Heredity.* **7** : 106-118.
3. Goldschmidt, R. B. (1955) Theoretical Genetics. Univ. of Calif. Press, U. S. A.
4. Harshberger, J. W. (1896) Fertile crosses of teosinte and maize. *Gdn. & Forest.* **9** ; 522—523.
5. Jones, D. F. (1956) Genic and cytoplasmic control of pollen abortion in maize. *Brookhaven Sym. in Biol.* **9** : 101—112.
6. Lysenko, T. D. (1950) Agrobiologia, 6. English translation, "New developments in the science of Biological species". Foreign languages Publishing House, Moscow (1951).
7. Lima-de-Faria, A; Sarvella, P. & Morris. R. (1958) Structural differentiation of the chromosome in different tissues. *Proceedings 10th Int. Cong. Genetics.* **11** : 171.
8. Maheshwari, P. (1952) Lysenko's latest discovery. The Conversion of Wheat into Rye, Barley and Oats. Nature. **170** : 66—68.
9. Mangelsdorf, P. C. (1947) The origin and evolution of maize. *Advances in Genetics.* **1** : 161—207. Academic Press Inc. New York.
10. Pavan, C. (1958) Morphological and Physiological aspects of chromosomal activities. *Proceedings 10th Int. Cong. Genetics.* **1** (Papers, Lectures etc.) : 321-336.
11. Randolph, L. F. (1955) History and Origin of corn. II, Cytogenetic aspects of the origin and evolutionary history of corn. In Corn & Corn Improvement, ed. G. F. Sprague. 16—61. Academic Press. New York.
12. Randolph, L. F. (1959) The Origin of maize. *Indian J. Genetics & Plant Breeding.* **19** : 1—12.
13. Reeves, R. G. & Stansel, R. H. (1940) Uncontrolled vegetative development in maize and teosinte. *Amer. Jour. Bot.* **27** : 27—30.
14. Reeves, R. G. & Mangelsdorf, P. C. (1942) A proposed taxonomic change in the tribe Maydeae (Family Gramineae). *Amer. Jour. Bot.* **29** : 815—817.
15. Rogers, J. S. (1950) The inheritance of photoperiodic response & tillering in maize—teosinte hybrids. *Genetics* **35** : 513—540.

16. Singh, B. & Paliwal, R. L. (1960) Studies on a luxuriant form of teosinte and its hybrids with maize. *Agra Univ. Jour. Res. (Science)* **9** : 137—146.

17. Waddington, C. H. (1955) The Strategy of the Genes. George Allen & Unwin Ltd. Londen.

18. Zirkle, C. (1951) The Knowledge of Heredity Before 1900. In "Genetics in 20th Century." Edited by L. C. Dunn. P : 35—57. Macmillan & Co.

Explanation of Plate No. I.

Figs. 1—6 : Meiosis in male sterile maize x teosinte hybrids; X 2100

Fig. 1 Diakinesis, showing 10 bivalents.

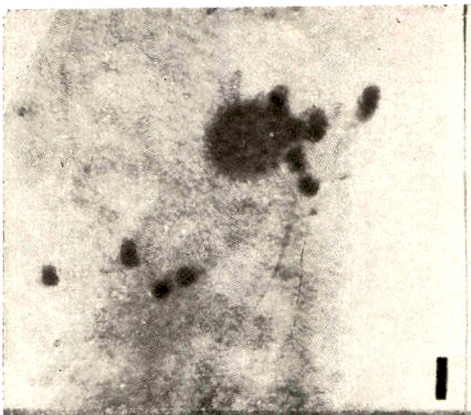
Fig. 2 Metaphase I, showing 10 bivalents.

Fig. 3 Diakinesis, showing 9 bivalents & 2 univalents.

Fig. 4 Metaphase I, showing 9 bivalents at the equator and 2 univalents, one at each pole.

Fig. 5 Metaphase I, showing 8 bivalents & 4 univalents, 3 at one pole and one at the other.

Fig. 6 Metaphase I, showing 9 bivalents at the equator 2 of which are showing precocious separation, & 2 univalents at the lower pole.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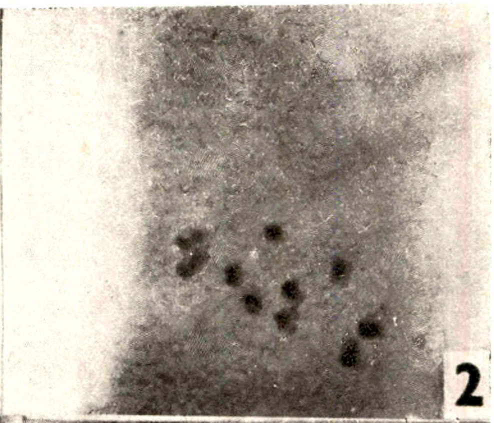
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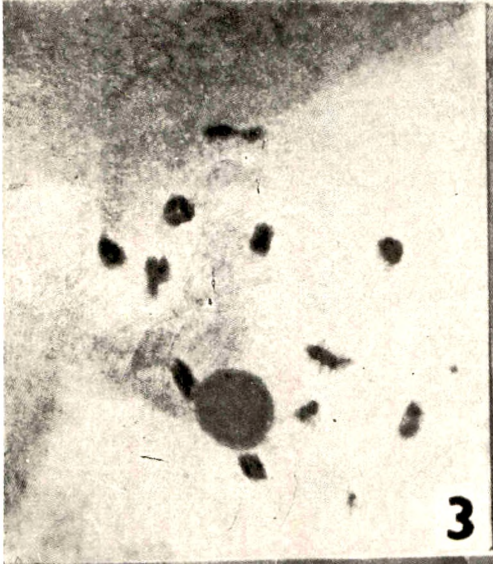
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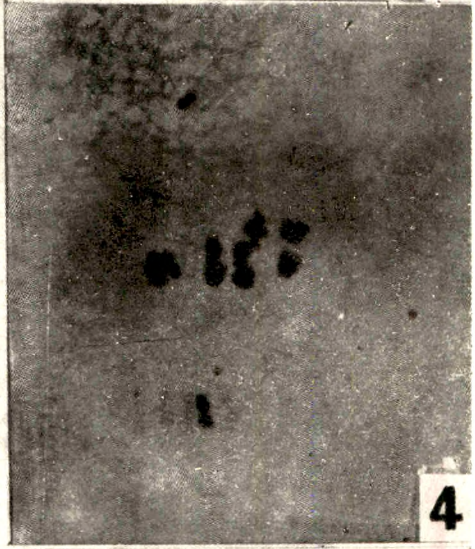
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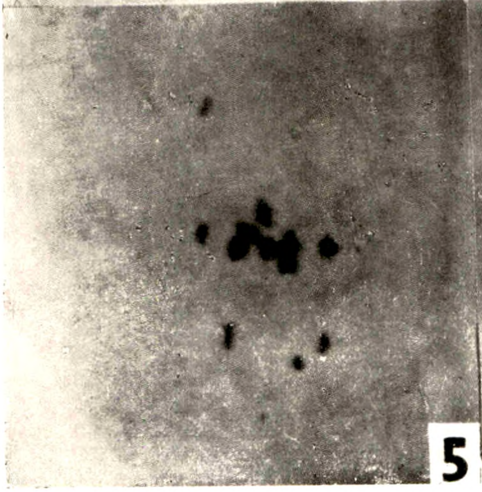
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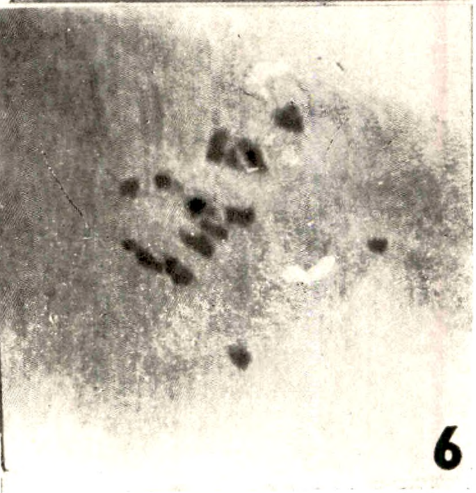
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Explanation of Plate No. 2.

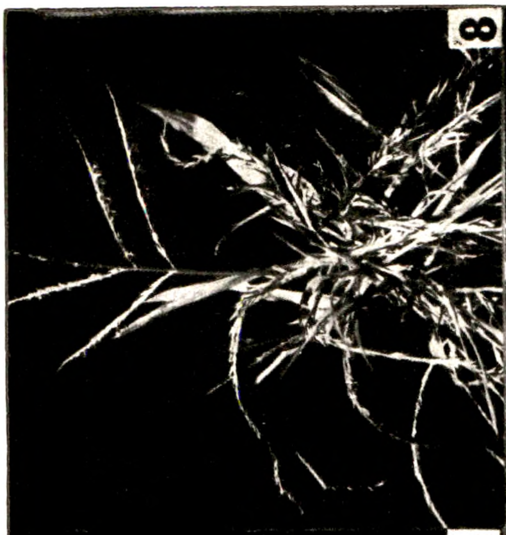
Figs. 7—10 : Showing the metamorphosis of tassels into bulbils.

Fig. 7 A tassel at the beginning of vegetative metamorphosis. Note the anthers hanging out from the florets in the upper spikes.

Fig. 8 A tassel showing some normal spikes, while others have already undergone vegetative development.

Fig. 9 A tassel showing vegetative development of glumes and lemma of each floret on all the spikes.

Fig. 10 A tassel at an advanced state of vegetative development.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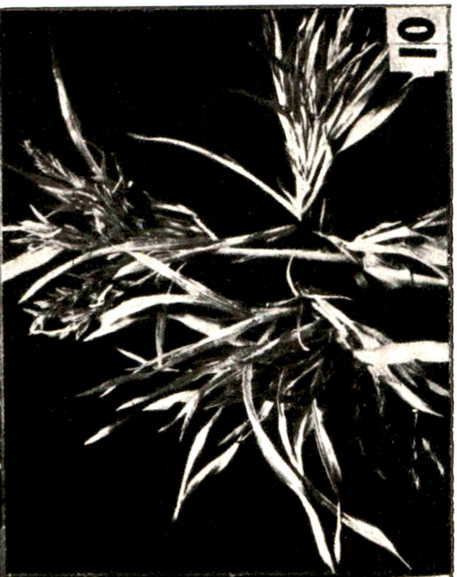
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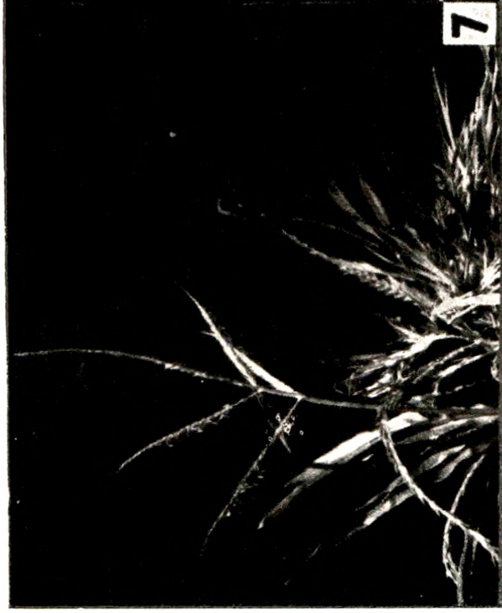
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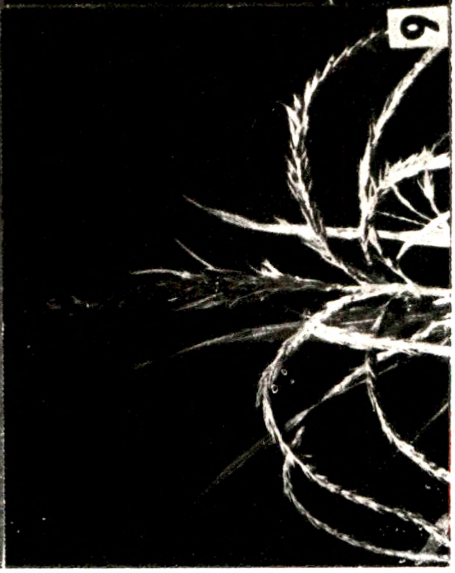
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Explanation of Plate No. 3.

Figs. 11—16 : Showing tassel bulbils with secondary inflorescences.

Figs. 11—12. Tassels at much advanced stage of vegetative development. In Fig. 11, note the secondary inflorescences with the terminal teosinte like female inflorescence. In Fig. 12 note the silks hanging from the secondary inflorescences.

Fig. 13. A branch of the bulbil showing axillary female inflorescences of hybrid nature.

Fig. 14. Two branches of the bulbils showing teosinte like female inflorescences borne at the apex of each branch. Note the silks hanging out from the axillary inflorescences below.

Fig. 15 Branches detached from the bulbil and grown in Knopp's solution.

Fig. 16 Branches detached from the bulbil and planted in pots. Note the silks hanging out from an inflorescence.

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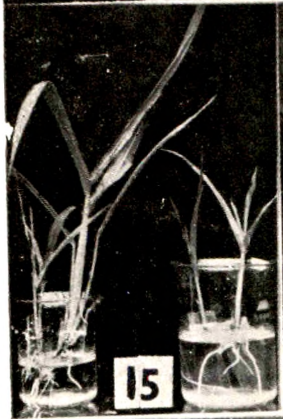
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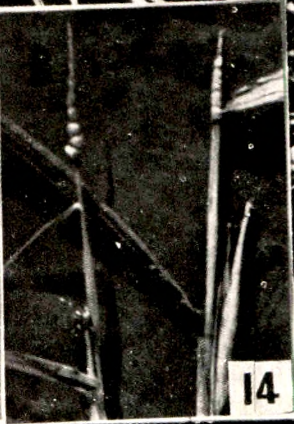
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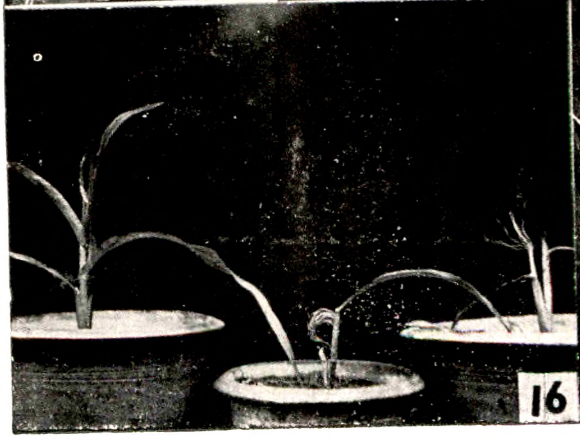
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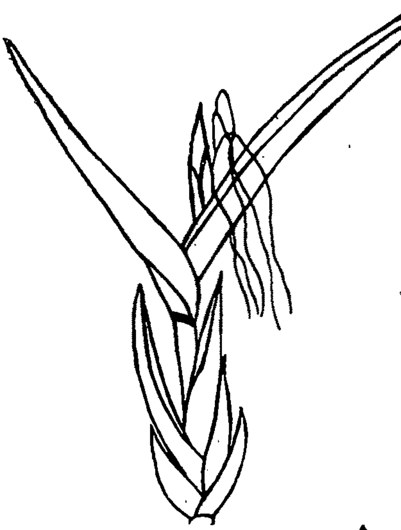
Diagrams A—C : Semidiagramatic drawings showing the details of an individual branch of a bulbil.

Diag. A An individual spikelet which has developed into a branch.

Diag. B Same as above, shown with glumes and lemma removed to expose the male flowers.

Diag. C A mature branch with secondary inflorescences. Each part has been shown separately in the order of development to show the position and details of each inflorescence.



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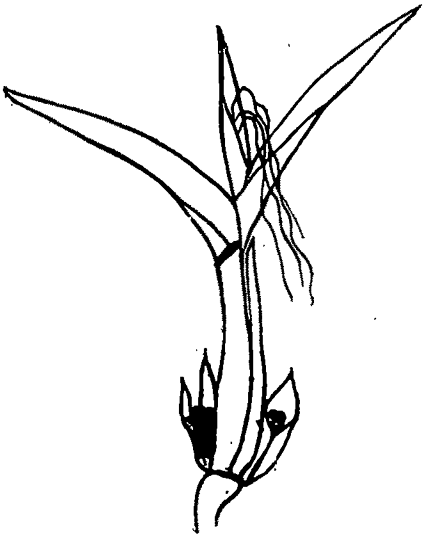

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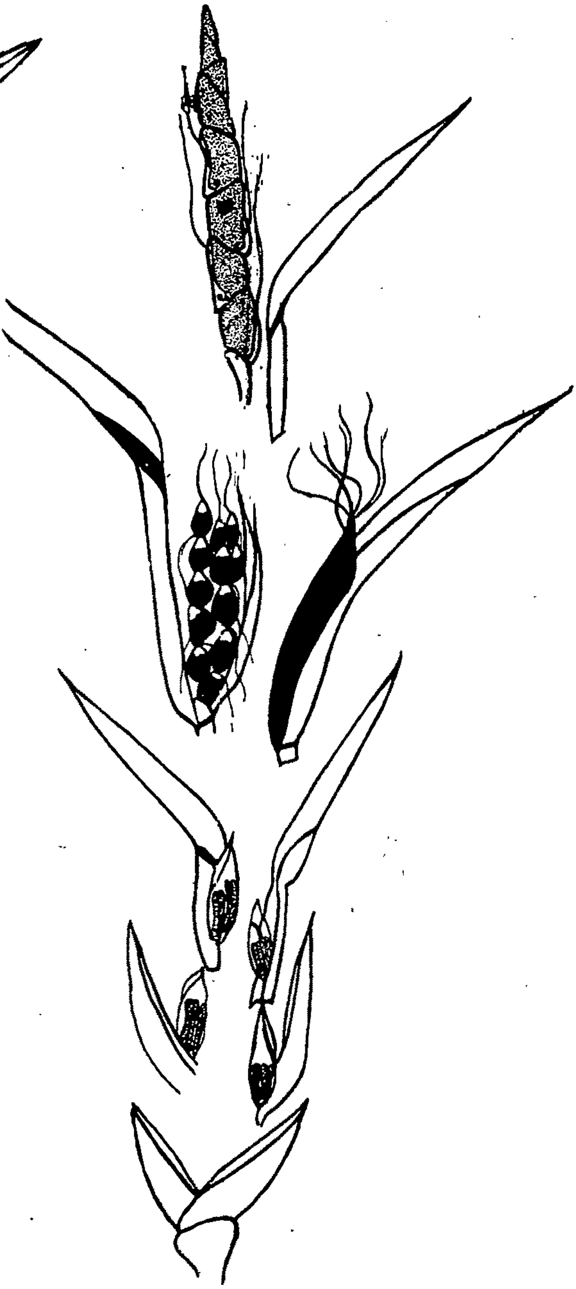

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SOME OBSERVATIONS ON THE OVULATION AND CORPUS LUTEUM FORMATION IN *COCCINELLA SEPTEMPUNCTATA* LINN. COLEOPTERA : COCCINELLIDAE.*

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I. Introduction.
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III. Description of the adult ovary.
IV. Oviposition.
V. Anatomy of Corpus luteum.
VI. Histology of Corpus luteum.
VII. Degeneration of follicle cells.
VIII. Summary.
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Introduction

Many authors, viz., Ahrens (1935), Wigglesworth (1936), Vel'tischev (1941), Palm (1948), Delerma (1951), Bonhag and Wick (1953), Dasgupta and Ray (1956), Singh (1958) and Waloff and Richards (1958) have reported the presence of Corpora lutea in different insect orders, but very little is known about its formation in the order Coleoptera, partly because not much is known about their life-histories and also due to their rearing difficulties. An attempt has been made in this paper to study the ovulation and Corpus luteum formation in *Coccinella, septempunctata* (Linn.). Here again it was difficult for the insect to survive in tubes after the first batch of eggs is laid and, therefore not much could be worked out regarding the second, third or successive Corpus luteum when the corresponding egg is laid from each ovariole.

Technique

The pupae of *Coccinella septempunctata* (Linn.) were collected from the fields at Agra. These were reared in large glass jars covered over by wire gauze at 28°C. and 40-45% R. H. Newly-hatched adult beetles were separated into pairs, a male and a female of the same age was kept in a small glass tube (2″ × 1″) covered over by a piece of muslin. The beetles were fed on aphids supplied every morning. The complete data of the histories of these pairs were recorded

Fixation and Microscopical Technique. Female beetles were dissected in Ringer's solution when 3 days old and subsequently one day after, to study

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* Contribution No. 85 from the School of Entomology, St. John's College, Agra.

the condition and size of the ovarioles. The ovarioles were then transferred into Bouin's fluid. 6—8μ thick sections were cut. Ehrlich's haematoxylin-Eosin and Mallory's Triple stain were used for staining.

DESCRIPTION OF THE ADULT OVARY

Each ovary consists of about 76 to 96 acrotrophic ovarioles. The ovarioles in a newly hatched beetle are whitish in colour, 0.5 mm. long, but the vitellarium and germarium are not distinguishable. The basal plug too is not prominent. Three days old ovarioles measure 0.57 mm. but without any perceptible change. On the 7th day, the ovarioles measure 0.75 mm. indicating the formation of the basal egg. By the 10th day the ovarioles reach almost maturity and divided into (i) Terminal filament, (ii) Germarium and (iii) Vitellarium measuring 0.97 mm. (Fig. 1). The germarium consists of undifferentiated cells while the vitellarium has one mature, well marked basal egg with egg follicle, yellowish in colour, due to the accumlation of yellow yolk granules. Distal to the basal egg is a much smaller, colourless egg$_2$ and next to it a very small egg$_3$ (Fig. 1). Never more than three oocytes are seen in the vitellarium and no nutritive strands are noticed. Basal plug is seen at the base of each mature egg. The ovariole opens into the lateral oviduct by a small tubular pedicle (Fig. 3).

OVIPOSITION

The tubes containing pairs of beetles were examined hourly to record oviposition. The eggs were laid on the surface of the green leaf, sides of the glass tubes but very rarely on the muslin covers. The maturation time of 35 females is given in Table I.

Table 1

Days after emergence :	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Number of females laying first batch of eggs :	8	6	5	4	3	1	1	2	1	1	1	0	1	0	1	0

From the table it is clear that the normal maturation time of the female beetles is 10-17 days and the beetles laying eggs after 17 days may be regarded having abnormal development. The eggs laid by a beetle and the ovarioles of the same were counted. Details of the counts are given in Table 2.

Table 2

Statement showing the number of eggs laid by a beetle in the 1st batch and the number of ovulated ovarioles.

Insect	Days after emergence 1st batch laid.	Total no. of eggs laid.	Ovulated ovarioles.	Unovulated ovarioles.	Total no. of ovarioles.
A	12	5	5	85	90
B	10	23	23	73	96
C	10	30	30	54	84
D	10	14	14	62	76
E	11	10	10	76	86
F	12	49	49	35	84
G	10	29	29	59	88
H	13	37	37	49	86
I	10	56	56	22	78
J	16	45	45	47	92
K	17	58	58	20	78
L	17	21	21	63	84
M	15	50	50	36	86
N	17/19*	46/38*	84	0	84
O	16/18*	26/66*	92	4	96

It is clear from the above observations that in the cases from A to M, the total number of eggs laid is not equal to the total number of ovarioles of that particular insect, but nevertheless the number of eggs laid in all these insects exactly corresponds to the number of ovulated ovarioles having a colourless corpus luteum at the base. A special attention is drawn towards the insects N and O, where eggs were laid in two batches with an interval of two days between the two egg layings. On dissecting these, it was revealed that the number of ovulated ovarioles exactly corresponded to the total number of eggs laid and thus these may be regarded as cases of partial egg layings. The ovarioles other than ovulated ones were considered as non-ovulated. From the egg counts and the number of ovulated ovarioles, it is clear that at each egg laying, a single egg is normally shed by an ovariole and many ovarioles do not ovulate. Singh (1958) observed the same behaviour in *Locusta migratoria.*

ANATOMY OF THE CORPUS LUTEUM

In immediately ovulated ovarioles a colourless corpus luteum is seen at the base measuring 0.22 mm. Dissections done one day and two days after ovulation revealed that corpus luteum contracts to 0.15 mm. and 0.17 mm. respectively. No pigmentation was ever observed in the corpora lutea. Similar observations were made by Singh (1954) and Waloff and Richards (1958) in Chrysomelid beetle, *Phytodecta olivacea.*

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* Denominators in columns two and three show the days after emergence and the number of eggs laid in second batch respectively.

HISTOLOGY OF THE CORPUS LUTEUM

At the time of maturation of the follicle, the nuclear material of the cells break down into enormous number of tiny basophilic granules, whereas the nuclear membrane is distinctly seen (Fig. 1). The tunica propria is 0.0014 mm. thick. When the mature egg is discharged from the follicle, the basal plug breaks off allowing the egg to pass into the pedicle. The second follicle becomes the basal follicle whose proximal end forms the follicular plug which takes the position of the basal plug (Fig. 2). Just after the discharge of the egg from the follicle the cells of the latter start degeneration by loosing its cellular nature and the lumen of the follicle starts getting filled with disintegrated deeply basophilic follicular nuclei and cytoplasm (Fig. 2), forming a corpus luteum. The corpus luteum is tubular and elongated with long and narrow lumen of the follicle indicating the site of discharge of the egg. The tunica propria which takes a blue colour when stained with Mallory's Stain, gets slightly thicker (0.0017 mm.) and wavy at the posterior and anterior ends. One day after ovulation, the corpus luteum contracts becoming smaller in length (Fig. 3). The lumen of the follicle is narrowed out and the space is filled by the rapid degeneration of the follicular nuclei. The nuclei are few and swelled up possessing few basophilic granules. The passage of the egg is still clearly seen in the conglomeration of the follicle cells. The thick (0.0032 mm.) tunica propria becomes wavy all over and fold-ed at the base (Fig. 3). Two days after the discharge of the egg, the corpus luteum becomes more compact, the tunica propria gets thicker (0.0051 mm.) and slightly folded on either side and most of the follicular nuclei and their cytoplasm get absorbed. The lumen of the follicle is no more visible (Fig. 4).

DEGENERATION OF THE FOLLICLE CELLS

At first the follicle cells loose their cellular nature and further show range of changes leading to complete degeneration. In some nuclei, a single compact mass is seen. In others swollen nuclei are detected with numerous small basophilic granules in them, while some show large nuclei with a few less stained granules leading to more or less complete absorption. The development of a compact mass, pyknosis (Wright, 1954) and the gradual disappearance of the nuclear granules, karyolysis (Wright, 1954) was observed exactly in the same manner as described by Singh (1958) in *Locusta migratoria* and *Schistocerca gregaria*.

SUMMARY

1. Each ovary consists of 76-96 ovarioles.
2. The females of *Coccinella septempunctata* (Linn.) lay the first batch of eggs normally between 10-17 days after emergence and the number of eggs laid is variable in different females.
3. Normally a single egg is shed by an ovariole and many ovarioles may not ovulate.

4. Corpus luteum is always colourless.
5. Thickening of tunica propria with the appearance of waves and folds are visible.
6. Histology of the follicle cells undergoing degeneration to form corpus luteum is described.

REFERENCES

1. Ahrens, W., 1935. Die Entwicklung des "Corpus luteum" bei den Insekten. Nack Untersuchungen an *Termes redemanni*. *Z. Mikr-ant. Forsch*, **37**: 467-500.
2. Bonhag, P. F. and Wick, J. R., 1953. The functional anatomy of the male and female reproductive systems of the Milkweed Bug, *Oncopeltus fasciatus* (Dallas). (Heteroptera : Lygaeidae). *J. Morph.*, **93**: 177-283.
3. De Lerma, B., 1951. Ricerche istochimiche sui "Corpi lutei" di Ortotteri con l'applicazione del test di schultz per le sostanze collesteroliche. *Boll. Zool. Torino*, **18**: 5-6
4. Dasgupta, B. and Ray, H. N., 1956. Observations on the 'Corpus luteum' and the 'NR bodies' in the Female gonads of bed-bug. Abstract of paper published in Proceedings of the 43rd Indian Science Congress (3) Sec.Zoo. and Ent. : 291.
5. Palm, N. B., 1948. Normal and pathological histology of the ovaries in *Bombus* Latr. (Hymenopt.). *Opusc. Ent. Lund.*, Suppl. **7**: 1-101.
6. Singh, T., 1958. Ovulation and Corpus luteum formation in *Locusta migratoria migratorioides* Reiche and Fairmaire and *Schistocerca gregaria* (Forskal) *Trans. R. ent. Soc. Lond.*, **110** (I) : 1-20.
7. Vel'tischev, P. A., 1941. New data on bio-ecology of the Asiatic locust in the Amu-Daryo delta. *Priroda* : 78-81.
8. Waloff, N. and Richards, O. W., 1958. The biology of the Chrysomelid Beetle, *Phytodecta olivacea* (Forster) (Coleoptera : Chrysomelidae). *Trans. R. ent. Soc. Lond.*, 110 (5) : 99-116.
9. Wigglesworth, V. B., 1936. The function of the corpus allatum in the growth and reproduction of *Rhodnius prolixus* (Hemiptera). *Quart. J. micr. Sci.*, **79** : 91-121.
10. Wright, G. P., 1954. An Introduction of Pathology, 2nd Edn. London, : 166-72.

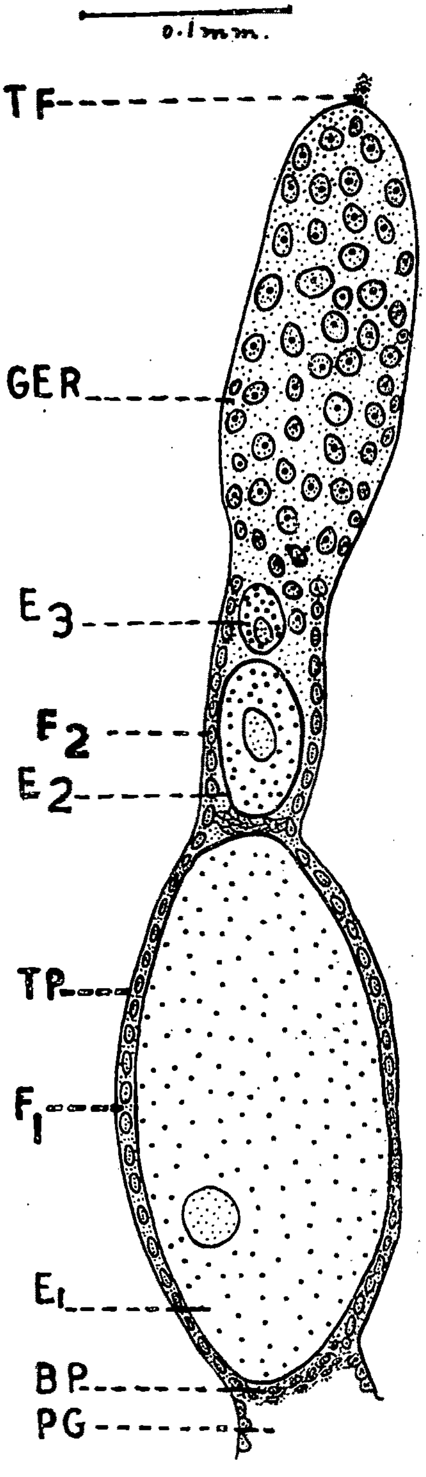

FIG. I

Fig. 1.—A mature acrotrophic ovariole.

BP—Basal plug.
E_1—First egg.
E_2—Second egg.
E_3—Third egg.
F_1—First egg follicle.
F_2—Second egg follicle.
GER—Germarium.
PG—Passage of egg.
TF—Terminal filament.
TP—Tunica propria.

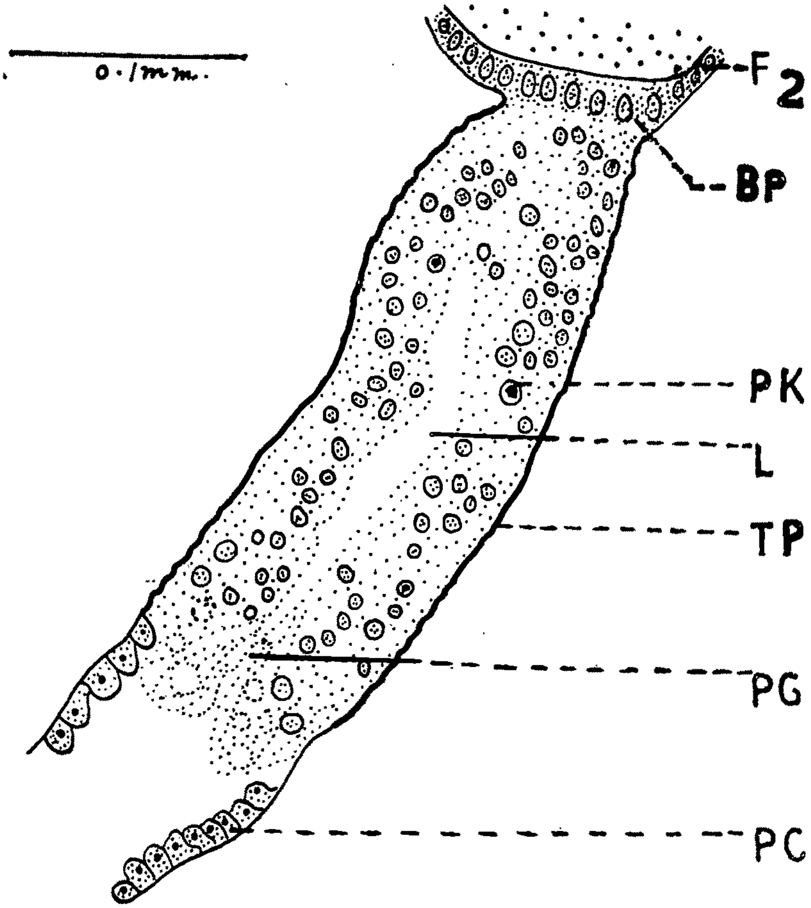

FIG. 2

Fig. 2.—Base of ovariole showing Corpus luteum immediately after ovulation.

BP—Basal plug.
F_2—Second egg follicle.
L—Lumen of the first follicle.
PC—Pedicle.
PG—Passage of egg.
PK—Pyknotic cell.
TP—Tunica propria.

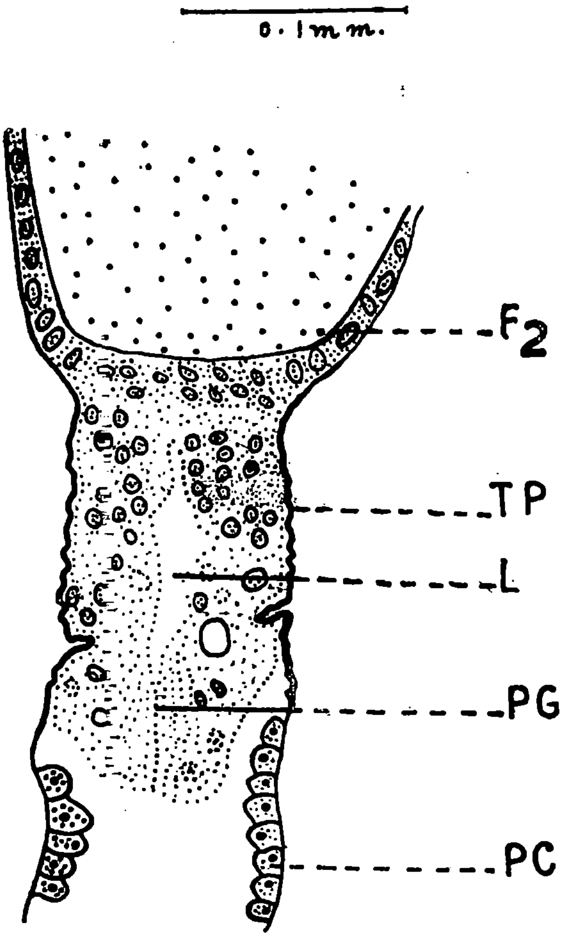

FIG.3

Fig. 3.—Base of ovariole showing Corpus luteum one day after ovulation.

F_2—Second egg follicle.
L—Lumen of the first follicle.
PC—Pedicle.
PG—Passage of egg.
TP—Tunica propria.

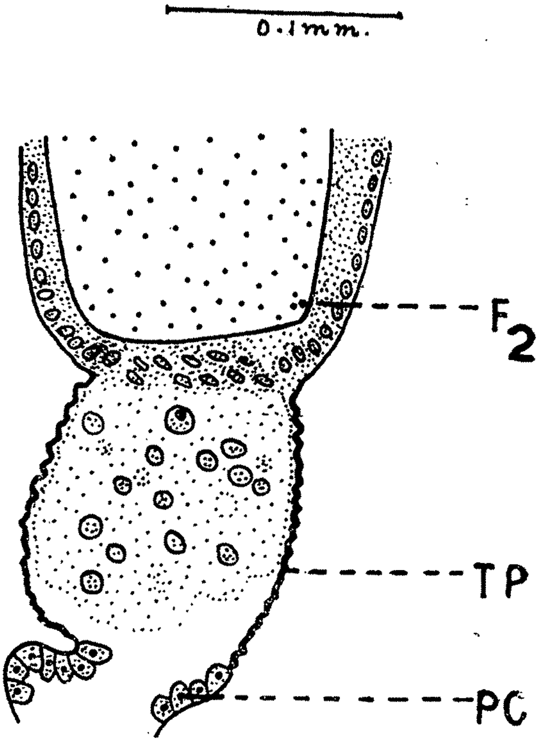

FIG. 4

Fig. 4.—Base of ovariole showing Corpus luteum two days after ovulation.

F_2—Second egg follicle.
PC—Pedicle.
TP—Tunica propria.

ENTOMOLOGICAL SURVEY OF HIMALAYA

Part XXXII.—A Note on the Larva of an apparently undescribed species of *Deuterophlebia* Edw. (Deuterophlebiidae: Diptera-Nematocera) from the North-West (Punjab) Himalaya.*

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This note contains a brief account of the most remarkable larva of an apparently undescribed species of the mountain-midge *Deuterophlebia* Edw., collected by Prof. M. S. Mani's Second and Third Entomological Expeditions to the Himalaya, during 1955-56. I thank Prof. M. S. Mani for placing the interesting material at my disposal for study and the authorities of the St. John's College for facilities for work.

Since Edwards (3) erected the family Deuterophlebiidae for the remarkable mountain-midge *Deuterophlebia mirabilis* Edw. from Kashmir in 1922, the larvae, pupae and adults of different species have been described from the Altai Mountain, North Korea, Japan, Canada and parts of the United States of America. The family contains at present the single genus *Deuterophlebia* Edw. with five species *D. mirabilis* Edw. (Kashmir), *D. nipponica* Kitakami (Japan), *D. tyronensis* Kitakami (North Korea), *D. coloradensis* Pennak (Colorado) and *D. shasta* Wirth (California) and four unnamed species known as larvae only.

Prof. Mani's Expeditions collected numerous examples of the larvae of an undescribed species from melt water torrents, both on the north slope of the Pir Panjal Range and on the south slope of the Great Himalaya in the Lahaul area, at elevations ranging from 3500 to nearly 4000 metres. This was the first time that the larvae were observed from India. The larvae were observed in company with the larvae and pupae of Blepharoceridae during the middle and end of June. The larvae were clinging to the upper surface of submerged stones near the edge of the torrents and close to the snow edge. The temperature of the water was 4·5°C. In all cases the larvae were conspicuously gregarious and were found to orientate themselves to face the strong current.

General characters. (Photomicrograph). The body is strongly arched dorsally. Head, thorax and abdomen are distinct and strongly marked off. The head is wider than long, bears long branched antennae. The thoracic segments are separated by a conspicuous lateral constriction. The abdomen consists of 8 distinct segments, each of first seven bearing a pair of stout and large lateral prolegs. The distal ends of the prolegs are provided with num-

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erou: concentric rings of characteristically shaped crochets, which function as organs of anchorage. The last abdominal segment is produced into paired terminal processes, reduced apically. This process bears ventrally five, soft, obtuse blood gills. The dorsal surface is finely and densely pubescent. The length of the body varies from 4.0 mm. to 4.5 mm. Freshly killed specimens and living larvae are pink coloured to light brown.

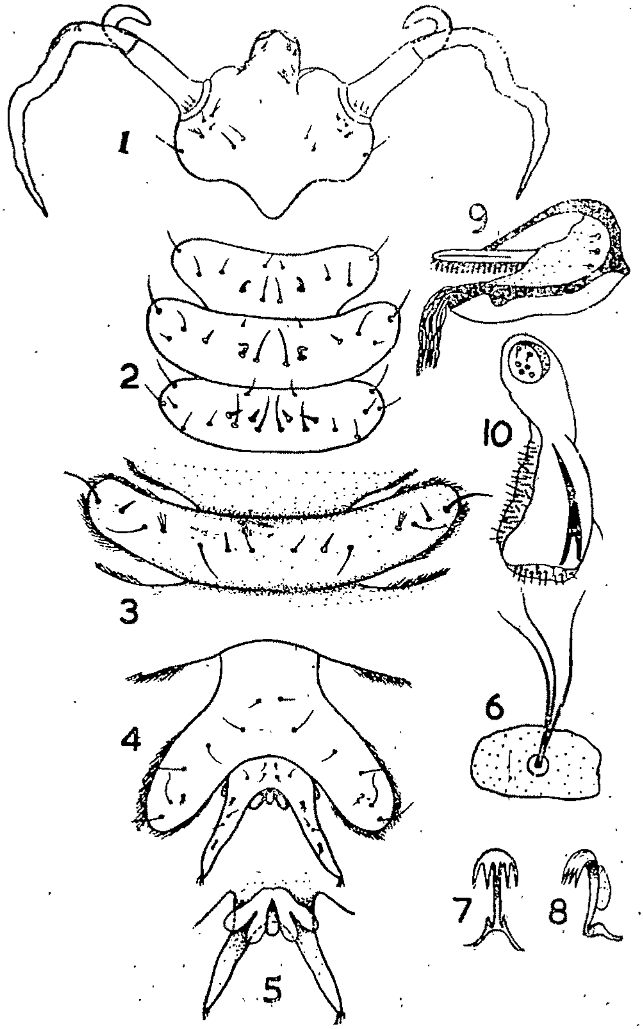
The head.—(Fig. 1) The head is the most densely sclerotized part of the body; it is freely movably articulated and is somewhat wider than long. The antennae consist of a basal cylindrical lobe, about four times as long as thick. Distally there are two soft and unsclerotized branches ; the ventral branch being about equal to the basal antennal segment and obtuse apically; the dorsal branch is about five times as long as the basal segment and strongly reduced apically. Brodsky (2) describes these branches as furnished with numerous sensory structures, but we believe them to have branchial function. Eyes are wholly absent. There are dorsally 4 tufts of short setae near the point of insertion of the antennae and 2 near the median line on each side. There are besides 4 setae on the clypeus, 2 near the proximal and 2 near the distal margin on each half. These setae have not been described by previous workers ; Pennak (7) however has referred to the tufts of setae on the head as being 9 instead of 8 in *D coloradensis*. In the present larvae the clypeus is a small rectangular piece with a notch in front.

The labrum is a membranous piece that projects in front ventrally from the clypeus like a proboscis in front of the mouth opening. There are two setaceous ridges on the epipharyngeal surface in a characteristic V-shape, the arms of the V diverging forwards. The setae on the ridges are arranged in transverse rows. Immediately behind the converging end of the ridges, there is a median lobe, which Pennak (7) considered as epipharynx and Pulikowsky (10) called hypopharynx.

The mandible is a cordate sclerotic ring, with a membranous lobe internally, bearing a comb with a double row of teeth, directed backward and inward. The base of the ring bears 3 setae as in fig. 9. Internally the ring bears a tuft of long ciliated setae, which serve to guide the food particles into the mouth cavity.

The maxillae are transverse and obtuse lobes with uniarticulate palpus, bearing numerous sensoria ; with an anterior comb of stiff bristles and mesially with a series of long bristles (Fig. 10).

The thorax.—The distinctly three thoracic segments are deeply constricted off from each other. The largest is the mesothoracic segment, both pro- and metathorax being small; the metathoracic segment is also the smallest. The prothorax somewhat overlaps the head from behind. The pro-, the meso- and metathoracic segments bear respectively 14, 14 & 20 setae dorsally (Fig. 2).



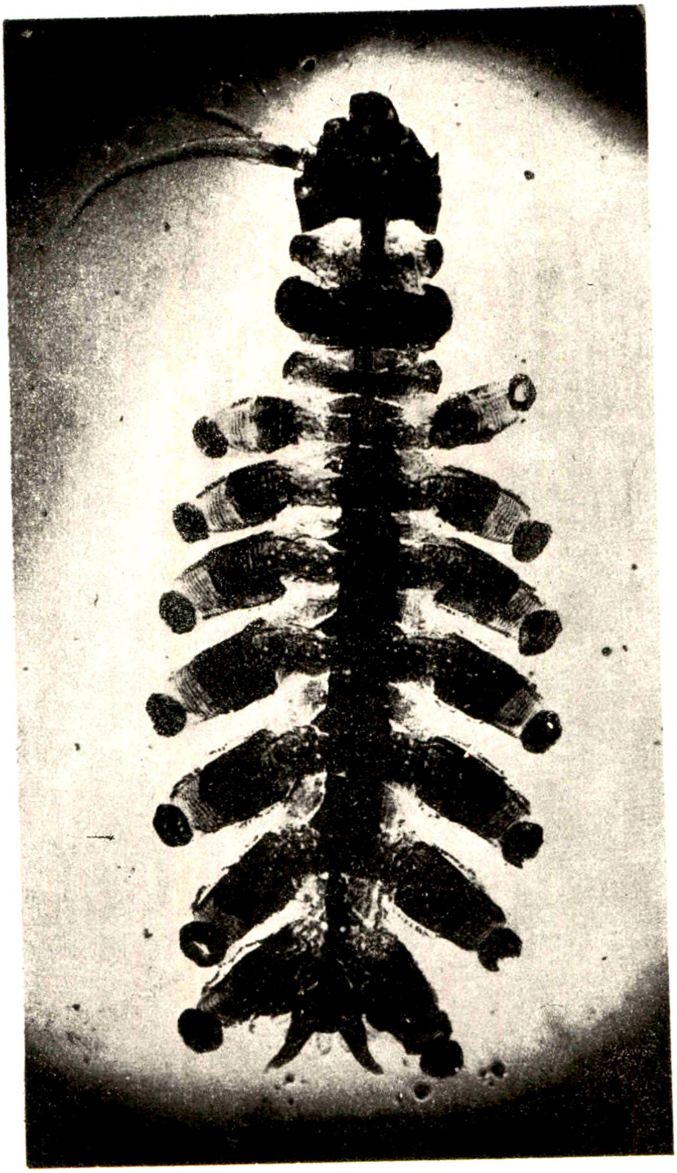
Figures 1-10. *Deuterophlebia* sp. 1. Head, 2. thorax, 3. a single segment of abdomen, 4. dorsal view of the terminal end of the abdomen of the larva, 5. ventral view of the terminal end of the abdomen showing the anal gills, 6. a magnified view of the tuft of setae, 7. a single crochet of the prolegs, 8. lateral view of the crochet, 9. mandible and 10. maxilla.

The abdomen is widest in the middle, with 8 segments. The first 7 segments with paired lateral sprawling prolegs, which arise as evaginations of bodywall. The prolegs curve downward distally and bear at the tip a series of concentric rings of peculiar minute crochets (figs. 7 & 8). Each crochet is roughly Z-shaped and consists of a curved, ctenoid portion, with 5 teeth and a flat, keeled pedicel, the basal portion of which is bifurcated. The crochets of the distal ring are the longest. The number of crochets rings ranges from 12 to 14, but varies from leg to leg and also in different instars. The variation is partly also due to the fact that most of the crochets are easily broken off even in course of normal locomotion of the larvae. At the tip of the proleg, concentric with the ring of crochets, there is a pad-like structure, which comes into contact with the substratum. This structure is moved by muscles that arise on the dorsum of the segment. The structure was believed by Pulikowsky (10) to have suctorial function and Pennak (7) also seems to share this view. I have however observed in the living larvae that the anchorage is secured only through the crochets and the pad-like structure does not produce any suction. The last abdominal segment is small and bears two pointed processes and 5 setae terminally (Fig. 4). Ventrally around the oval anal opening, there are obtuse lobes ; four of these lobes are paired at the sides and the fifth is median and function as blood gills (fig. 5). The tips of the malpighian tubules project into the lumen of these lobes.

The larvae differ from those of other known species in the different proportions of the antennae.

REFERENCES

1. Brodsky, A. & K. Brodsky. 1926. *Deuterophlebia* dans les montagnes de l 'Asie Centrale. *Bull. Univ. Asie Centr.*, 13: 23-26.
2. Brodsky, K. 1930. Zur Kenntnis der Wirbellosenfauna der Bergströme Mittelasiens. II. *Deuterophlebia mirabilis* Edw. *Z. Morphol. Ökol. Tiere*, 18 : 289 - 321.
3. Edwards, F. W. 1922. *Deuterophlebia mirabilis*, gen. *et. sp.* nov., a remarkable dipterous insect from Kashmir. *Ann.Mag. Nat. Hist.*, (9) 9: 379-387.
4. Kitakami, S. 1929. An unusual insect from Japan (Diptera : Deuterophlebiidae). *Zool. Mag.*, 41 : 379-380.
5. Kitakami, S. 1938. The Deuterophlebiidae of Japan. *Annot. Zool. Japonensis*, 17 : 487-513.
6. Muttkowski, R. A. 1927. A new and unusual insect record from North America (Diptera : Deuterophlebiidae). *Bull. Brooklyn. Ent. Soc.*, 22: 245-249.
7. Pennak, R. V. 1945. Notes on mountain midges (Deuterophlebiidae) with a description of the immature stages from Colorado. *American Mus. Nov.*, 1276 : 1-10.
8. Pennak, R. V. 1950. First record of adult mountain midges from North America. (Diptera : Deuterophlebiidae) *Ent. News*, 61 : 36.
9. Pennak, R. V. 1951. Description of the imago of the mountain midge *Deuterophlebia coloradensis* Pennak (Diptera : Deuterophlebiidae). *American Mus. Nov.*, 1534 : 1-11.
10. Pulikowsky, N. 1924. Metamorphosis of *Deuterophlebia* sp. (Diptera: Deuterophlebiidae). *Trans. ent. Soc. London.* pp. 45-62).
11. Shelwell. 1954. First record of Deuterophlebiidae in Canada. *Canad. Ent.* 86 : 204-206.
12. Stone, A. 1949. *Deuterophlebia coloradensis* Pennak in Oregon. *Proc. ent. Soc. Washington*, 51 : 122.
13. Wirth, W. W. 1951. A new mountain midge from California (Diptera:Deuterophlebiidae) *Pan-Pacific Ent.* 27 : 49-57.
14. Yie, S. 1933. Observations on a Japanese *Deuterophlebia* (Diptera). *Trans. nat. Hist. Soc. Formosa*, 23 : 271-296.



Photomicrograph of the *Deuterophlebia* sp. larva. The actual length of the larva is 4.0 mm.

EXTERNAL MORPHOLOGY OF THE HEAD CAPSULE OF THE FRUIT-FLY *DACUS DIVERSUS* COQ.

(TRYPETIDAE : DIPTERA)*

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INTRODUCTION

This paper summarizes the results of my studies on the morphology of the head capsule of fruitfly, *Dacus diversus* Coq. A persual of the literature reveals that, while biology and taxonomy of fruitflies have received considerable attention, morphological studies have been relatively neglected. Miyake (1919) was perhaps the first to contribute to our knowledge of external and internal morphology of fruitflies from Japan. Costantino (1930) described the general morphology of *Ceratitis capitata* Wied. Samoggia (1932) gave a sketchy account of the head and abdomen of *Rhagoletis cerasi* L. Kobayschi (1934) made a special study of the alimentary canal and nervous system of Trypaneidae. Hanna (1939) worked out the structure and operation of reproductive organs of *C. capitata* Wied. Renjhen (1949-50) studied the morphology of the immature stages of *Dacus* (*Strumeta*) *cucurbitae* Coq.

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MATERIAL AND METHOD

The fruitflies collected from *Luffa aegyptiaca* Mill. in Hoshiarpur District (Panjab), were treated with 10% cold KOH for 24 hours, neutralised in acetic acid, upgraded and preserved in glycerine. The diagrams were drawn with the help of a graph eye-piece.

THE HEAD

The head is hypognathous, somewhat oval, flattened posteriorly and convex anteriorly. The proboscis remains suspended from the ventral rim of the head capsule. When not in use, it is retracted and folded along the ventral membranous surface. The prominent compound eyes (Figs. 1 and 3, CE) are non-confluent, and impart a deep blackish tinge to the ommatidia. The head as a whole is capable of movement only in the vertical plane. The head is 0.93 mm long and 1.39 mm wide in male, and 0.93 mm long and 1.86 mm wide in female.

1. *Sutures and Sclerites.*—The vertex (Figs. 1 and 3, VTX) has three ocelli in a triangle, the lateral ocelli (Figs. 1 and 3, LOC) above and infront of the median ocellus (Figs. 1 and 3, MOC). This area is called the ocellar plate by Munro (1947). It does not bear any ocellar bristles. Below the vertex the area in between the compound eyes is the frons. According to Ferris (1950) in *Drosophila* the frons is divided into the 'post-frons' (Figs. 1 and 3, POF) and the 'pre-frons' (Figs. 1 and 3, PREF). The latter is the area between the vertex and the ptilinal suture (Figs. 1 and 3, PTS) and the former is the area below the ptilinal suture extending upto the clypeus (Fig. 1, CLY). The 'post frons' bears the pair of antennae, but Miyake (1919) regards frons as the area in front of the vertex in *D. tsuneonis*. The ptilinal suture is prominent, ∩—shaped, situated above the antennae, with the arms of the ∩ extending down to genae (Figs. 1 and 3, GE). It marks the position of the ptilinum (Fig. 7, PTL) in the cyclorrhaphous flies. There is a V-shaped area just above the insertion of the antennae called the frontal lunule (Figs. 1 and 3, LU) Imms (1957). The genae are narrow sclerites.

In the absence of the epistomal suture, the frons and the clypeus are not clearly demarcated from each other. The anterior tentorial pits (Figs. 1, 2 and 4, ATP), one on either side of the margin of the cranium, inner to and below the ptilinal limb, however, mark the proximal limits of the clypeus (Fig. 1, CLY). The membranous area below the frons has been termed as peripheralclypeal membrane by Snodgrass (1944). In this area lies the inverted V-shaped sclerite the clypeus. While agreeing with Snodgrass in calling the sclerotized piece as clypeus, Duporte (1946) does not refer to the nature of the surrounding membrane. On the other hand, Miyake (1919) maintains the whole area below the antennae as the clypeus or the face, a view that seems untenable, as the clypeus is distinctly marked in the membranous area. In Brachycerous Diptera the labral muscles take their origin on it.

Posteriorly, the occipital foramen (Figs. 1 & 4, OCCF) is comparatively a small structure in the centre of the head. It is bounded dorso-laterally by a ∩-shaped narrow postocciput (Figs. 1 and 4, POCP), with its lateral arms reaching up to the level of the posterior tentorial pits (Figs. 2 and 4, PTP). The post-occipital suture (Figs. 2 and 4, POS) is very distinct. The lower ends of the postocciput are slightly widened to form the occipital condyles (Figs. 2 and 4, OCC). The occipital suture being absent, the occiput and the vertex are confluent. The former is bounded laterally by prominent sutures from the terminal ends of the postocciput and reaching up to the vertex between the bases of the outer and inner vertical bristles (Figs. 1, 2, 3, 4 & 7, OV and IV). The distal arms of these sutures disappear in the vertex. Ferris (1950) refers to these sutures in *Drosophila* as the premandibular sutures and the area enclosed by them as the occiput, Arora (1953) terms them in sawflies as temporal sutures, enclosing the occiput between them. On the basis of their location on the head capsule, it seems reasonable to consider them as temporal sutures. The temporal suture seems to have been overlooked by Hewitt (1914), Miyake (1919), Munro (1947) and West (1951). The area enclosed by these sutures has been a source of controversy. Snodgrass (1935), Arora (1953) and Ferris (1950) regard it as the occiput, but Hewitt and Lowne (as referred by Miyake, 1919) call it the epicranium or the mesocranium plate. The ventral border of the occipital foramen is supported internally by a heavily sclerotized transverse arch, the body of the tentorium (Figs. 2 and 4, CORPT). The areas lateral to the temporal sutures (Figs. 2 and 4, TPS) represent the postgenae (Figs. 2 and 4, PGE). These areas were called genae by Hewitt or paracephala by Lowne (described by Miyake, 1919). This discrepancy in the difference of nomenclature seems to be due to the absence of occipital sutures separating the genae from the postgenae, but a row of bristles along the posterior border of each eye (postorbital bristles) probably mark the posterior limit of the gena of that side ; and the lateral areas are thus the postgenae, which meet postero-ventrally to form the postgenal bridge or hypostomal bridge (Figs. 2 and 4, HYB) between the foramen and the labium. Such a condition is characteristic of some of the heads of Lepidopterous larvae and heads of adult Hymenoptera, Diptera and Heteroptera. The postgenal bridge bears two prominent, large and a number of small bristles. The postgenal bridge has been termed as gulomental plate by Miyake (1919) and gulomentum by Munro (1947). In the absence of elongated posterior tentorial pits (gular sutures) bounding the region on either side, one is not favourably inclined to accept these interpretations.

2. *The Chaetotaxy.*—The chaetotaxy of the head, important from the systematic point, comprise the following :—

(i) *Inner verticals.*—(Figs. 1-4 & 7, IV). A pair of long bristles at the distal margin of the occiput.

(ii) *Outer verticals.*—(Figs. 1, 2, 3, 4 & 7, OV). A pair of bristles, a little smaller than the inner verticals on the vertex just outside the occiput, outer to the inner vertical-bristles.

(iii) *Fronto-orbitals.*—Three pairs of bristles half the size of the inner verticals on the lateral sides of the frons and divided into two categories:

(a) *The Upper Orbitals or the Supra Orbitals.*—(Figs. 1, 3 & 7, UO). A pair of bristles slightly longer than lower orbitals, lie just below the vertex and directed outwards and upwards.

(b) *The Lower Orbitals or Infra Orbital bristles.*—(Figs. 1, 3 & 7 LO). Arranged in two pairs and directed inwards.

(iv) *Occipital bristles or the occipital comb.*—(Figs. 2 & 4, OB). A transverse row of small bristles on the base of occiput on either side constitute a comb containing 7-8 bristles on each side.

(v) *Post orbitals or occipitals.*—(Figs. 2 & 4, PO). Minute bristles on the genae forming a row all along the posterior margin of the eye.

(vi) *Post-genals.*—(Figs. 2 & 4, PG). Moderately prominent bristles, arranged in a row along the posterior margin of the postgena. Such a distinct structure seems to have escaped observation so far. These are being recorded for the first time.

(vii) *Gular bristles.*—(Figs. 2 & 4, GB). A pair of prominent bristles one on either side of the mid-ventral line, on the postgenal bridge.

3. *The Tentorium.*— (Figs. 2, 4 & 9). The tentorium is a sclerotized structure and attached along the ventral border of the occipital foramen (Figs. 1 & 4, OCCF). It has the usual three pairs of arms *viz.* the posterior, the anterior and the dorsal. The posterior tentorial arms arise form the posterior tentorial pits (PTP) and run inwards, uniting medially to form a transverse bar called the tentorial-bridge or the body of the tentorium (Corpotentorium) (CORPT), marking the ventral border of the occipital foramen. Close to its outer ends are attached the anterior tentorial arms (ATA). The anterior tentorial arms, which arise from the anterior tentorial pits (Figs. 1, 2, 4 & 9, ATP) are long, slender and extend along the inner wall of the postgenal areas, with their proximal part free and the distal part slightly attached to the inner wall of the cranium. The dorsal tentorial arms (Fig. 9, DTA) spring from the anterior tentorial arms just where the latter meet the corpotentorium. The dorsal tentorial arms are extremely slender and small.

THE HEAD APPENDAGES

1. *The Antennae.*—(Fig. 8). The antennae are black, pubescent and three segmented. Antennal sockets (AS) almost contiguous. The antennal

suture of the antennal socket is produced into a submarginal ridge, with a small pivot-like antennifer (AFTF) for attachment to the base of the scape (SC). The scape is the smallest segment and is slightly shorter than the pedicel (PDC), bearing 5-6 long bristles terminally. The second antennal segment is slightly longer than scape; narrow proximally and broad distally, with distal end about twice as thick as base with 6-7 bristles on the outer margin and 7 bristles on inner edge. The terminal antennal segment (FLG), is the longest, about twice as long as the first two segments combined, and approximately one-third as thick as long. Two-segmented arista (ART), devoid of pubescence, arises dorsally from the outer margin near the base of flagellum. The first segment of arista is very small and about one-fourteenth the length of the second thread-like segment.

2. *Mouthparts.*—(Figs. 1, 2, 5, 6 & 7). The mouthparts are of the muscoid sponging type and consist of a pendulus proboscis, kept folded against the ventral wall of the head capsule when not in use. The proboscis is a composite structure, formed of the labrum-epipharynx (LAEP) and labium-hypoharynx (LAHY), and supported on a membrane. The mandibles are absent, but the maxillae are represented by single-segmented maxillary palp (MAXP). The terminal end of the proboscis being short and broad, the whole structure was classified by Munro (1947) as capitate type. The proboscis consists of the following three portions :—

1. The large basal portion, the basiproboscis or rostrum.
2. The middle portion, the mediproboscis or haustellum.
3. The terminal distiproboscis or labella or lobes of the oral sucker.

(i) *Basiproboscis.*—It costitutes the basal membranous cylindrical portion of the proboscis. Its anterior wall contains an inverted U-shaped sclerite, which represents the clypeus. The posterior and lateral walls of it are all membranous. Just ventral and lateral to the terminal ends of the clypeal arms arise a pair of single segmented, highly sclerotized lobe representing the maxillary palp. Maxillary palp is three times as long as thick and is fringed with minute setae along the outer margin. In addition to these setae the rest of the surface is clothed with fine pubescence.

(ii) *The Mediproboscis.*—It is the middle cylindrical portion and is attached to the distal rim of the rostrum by a sclerotization of the rostral membrane. When the proboscis is stretched, it projects downwards from the distal end of the rostrum but lies folded along the anterior surface of the latter in the retracted condition. The flap-like labrum-epipharynx (Figs. 1 & 5, LAEP) covers the anterior side and is bifid at its tip. It has a pair of internal sclerotized apodemal rods, the labral apodemal rods (Figs. 2, 5& 6, LABAP) of Snodgrass (1944) at the angles of its base, for the attachment of the muscles. The longitudinal groove extends along the inner surface of the labrum-epipharynx, with the paired ridges (Fig. 5, LR) resting on the labium-hypopharynx (Fig. 5, LAHY) below enclosing the food channel between them. The hypopharynx is absolutely fused with the inner wall of the labium. Arora (1956) also observed similar fusion in the higher insects but Miyake (1919) escaped such an observation. The wall of the hypopharynx is supported by the lateral suspensorial-rods (Fig. 5, SUSR), formed by the thickening of the lateral labial margins. The labium is constituted by the basal postmentum (Fig. 7, PM), and the distal prementum (Fig. 7, PREM), the latter bearing thc oral lobe. The postmentum constitutes the posterior wall of the rostrum and is fused with the postgenal bridge proximally. The prementum is covered on the posterior side by a sclerotised plate called theca by Snodgrass (1943-44) and Miyake (1919); Munro (1947) called it mentum (Figs, 6 and 7, MNT). The theca bears a pair of small processes one on either side known as the cornua (Figs. 2 and 6, COR) meeting the furca (Figs. 2, 6 and 7, FRA), the supporting sclerite of labella (Figs. 1, 2, 5, 6 & 7, LA).

(iii) *Th? Distiproboscis.*—It is the apical sucking part of the proboscis, called oral disc or oral sucker by Snodgrass (1944) or oral lobe or labella by others. The two membranous labial palps (Crampton 1923 & 1924) or paraglossae of others unite to form the oral disc with a cleft in between, lying at the entrance to the food canal of the proboscis. The inner surface of these is grooved by a number of canaliculi called pseudotra cheae (Figs. 1, 2, 5 & 6, PSEUT), which converge at the oral aperture to convey the liquid food to the mouth. The oral disc is supported by a triangular sclerotized structure called the furca attached to the mentum (Figs. 2 and 6, MNT). The fine promi nent bristles fringe on the margins of labella.

The sucking apparatus or the cibarial pump (Figs. 2 & 6, CIBP) is an elongated chamber, with paired dorsal and ventral processes called the cornuae (Figs. 2 & 6. COR). The pre-oral part of the food canal of the proboscis leads proximally into the cibarial pump with a small chamber, the siphon (Figs. 2 & 6, SPH) of Snodgrass (1944). The lateral walls of the pump are fused with the clypeus by a pair of lateral plates (Fig. 6, LATP) running as inflections of the wall of the latter forming the fulcrum for the movements of the proboscis.

SUMMARY

The head of *Dacus diversus* Coq. is hypognathous, with the proboscis suspended from its lower membranous region. The compound eyes occupy the sides of the head and three ocelli are borne on the vertex. The U—shaped ptilinal suture, on the anterior face of the head, divides the frons into two regions. The epistomal suture is absent and the clypeus is distinctly separated from the frons. The tentorium is a sclerotized π—shaped structure, composed of three pairs of arms. The mouthparts are typical sponging type.

ACKNOWLEDGMENTS

I am deeply grateful to Dr. T. Singh, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra for his valuable guidance, facilities for work and constructive criticism in writing this paper. My sincerest thanks are also due to Dr. G. L. Arora, Reader in Entomology, Department of Zoology, Panjab University, Chandigarh for suggesting the problem and valuable advice.

REFERENCES

1. Arora, G. L. 1953. The external morphology of *Diprion pini* (L.). *Res. Bull. E. Panj. Univ.*, **25** : 1-21.
2. Arora, G. L. 1956. The relationship of Symphyta (Hymenoptera) to other orders of insects on the basis of adult external morphology. *Res. Bull. E. Panj, Univ.*, **90** : 85-119.
3. Bezzi, M. 1913. Indian Trypaneids (fruitflies) in the collection of the Indian Museum, Calcutta, *Mem. Indian Mus.*, Calcutta, **3** : 53-168
4. Bezzi, M. 1915. On the Ethiopean fruitflies of the genus *Dacus. Bull. ent. Res., London*, **6** : 85-101.
5. Bezzi, M. 1924. South African Trypaneid Diptera in the collection of the South African Museum, *Ann. S. Africa Mus. Cape Town*, **19** : 449-577.
6. Costantino, D. Giorgia. 1930. Contributo atta Comoscenza della mosa delle frutta (*Ceratitis capitata* Wied). *Bull. Lab. Zool. Portici*, **23** : 237.
7. Cramptono, G. C. 1923. A comparison of the labium in certain holometabolous insects from the standpoint of phylogeny. *Proc. ent. Soc. Washington*, **25** : 171-180.
8. Crampton, G. C. 1925. A phylogenetic study of the labium of holometabolous insects, with particular reference to the Diptera. *Proc. ent. Soc. Washington*, **27** : 68-91.
9. Duporte, E. Melville. 1946. Observations on the morphology of the face of Insects. *J. Morph.*, **79** : 391.
10. Ferris, G. F. 1950. External morphology of *Drosophila* given in the biology of *Drosophila*. Edited by M. Demerec, N. Y. John Willy & Sons, Chapman & Hall Ltd., London.
11. Hanna, A. D. 1939. Studies on the mediterranean fruit-fly *Ceratitis capitata* Wied. The study and structure of reproductive organs. *Bull. Soc. Fouadler Ent. Cairo*, **22** : 39.
12. Hewitt, C. Gardon. 1914. The House-fly *Musca domestica* Linn. Its structure, habits, development, relation to disease and control. Cambridge Zoological series, Cambridge Uni. Press.
13. Imms, A. D. 1957. A General Text Book of Entomology, Methuen & Co. Ltd., London.
14. Kobayashi, Kwan-ichi. 1934. Studies on the internal anatomy of the Trypetidae. *Trans. Nat. Hist. Soc. Formosa*, **24** : 136.
15. Lowne, B. T. 1892. The anatomy, physiology, morphology and development of the blow-fly. **1** : 350.
16. Miyake, T. 1919. *Bull. Imperial Central Agri. Experiment Sta. Japan*, **2**, No. 2.

17. Munro, H. K. 1947. Memoirs of the Entomological Soc. of Southern Africa. African_Trypetidae : Diptera. Published by the P. O. Box 103, Pretoria Union of South Africa No. 1.

18. Renjhen, P. I. 1949-50. On the morphology of immature stages of *D.* (*Strumeta*) *cucurbitae* Coq. and with notes on its biology. *Indian J. Ent.*, **11** : 83-100.

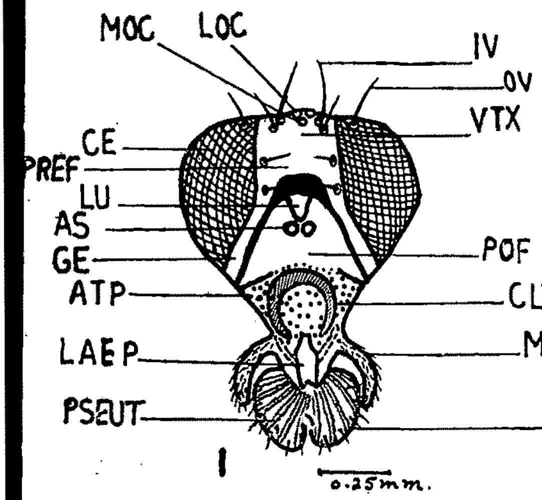
19. Samoggia, A. 1932. Nota sulla *Rhagoletis cerasi L. Bcll Lob. Ent. Bologna,* **6.**

20. Snodgrass, R. E. 1935. Principles of Insect Morphology. McGraw Hill Book Co., New York and London.

21. Snodgrass, R. E. 1943. The feeding apparatus of biting and disease-carrying flies : A wartime contribution to medical Entomology. *Smithson. Misc. Coll.*, **104.** No. 1.

22. Snodgrass. R. E. 1944. The feeding apparatus of bitting and sucking insects affecting man and animals. *Smithson. Misc. Coll.*, **104,** No. 7.

23. West, Luther S. 1951. The house-fly, its natural history, medical importance and control. Comstock publishing Co. Inc., New York.



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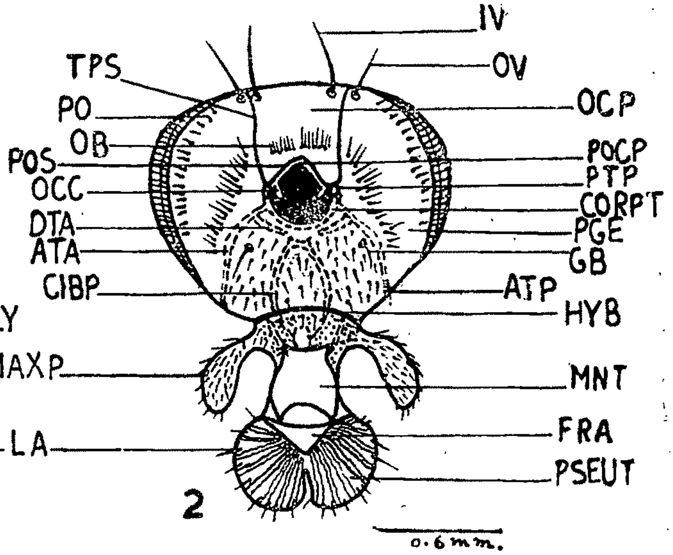

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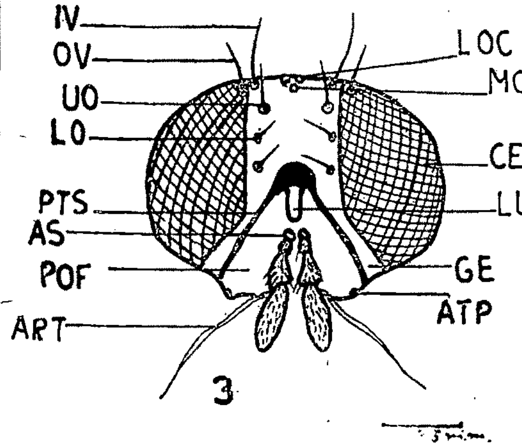

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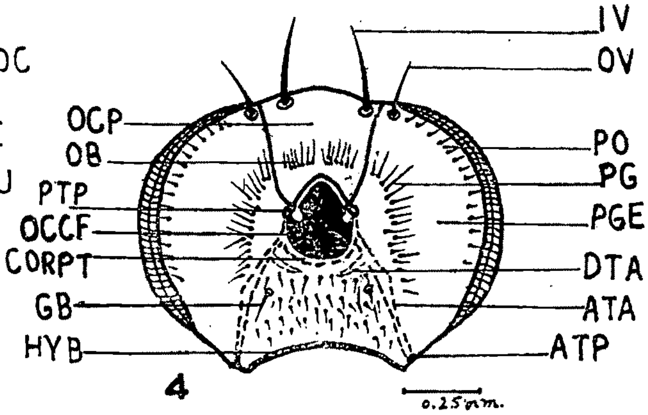
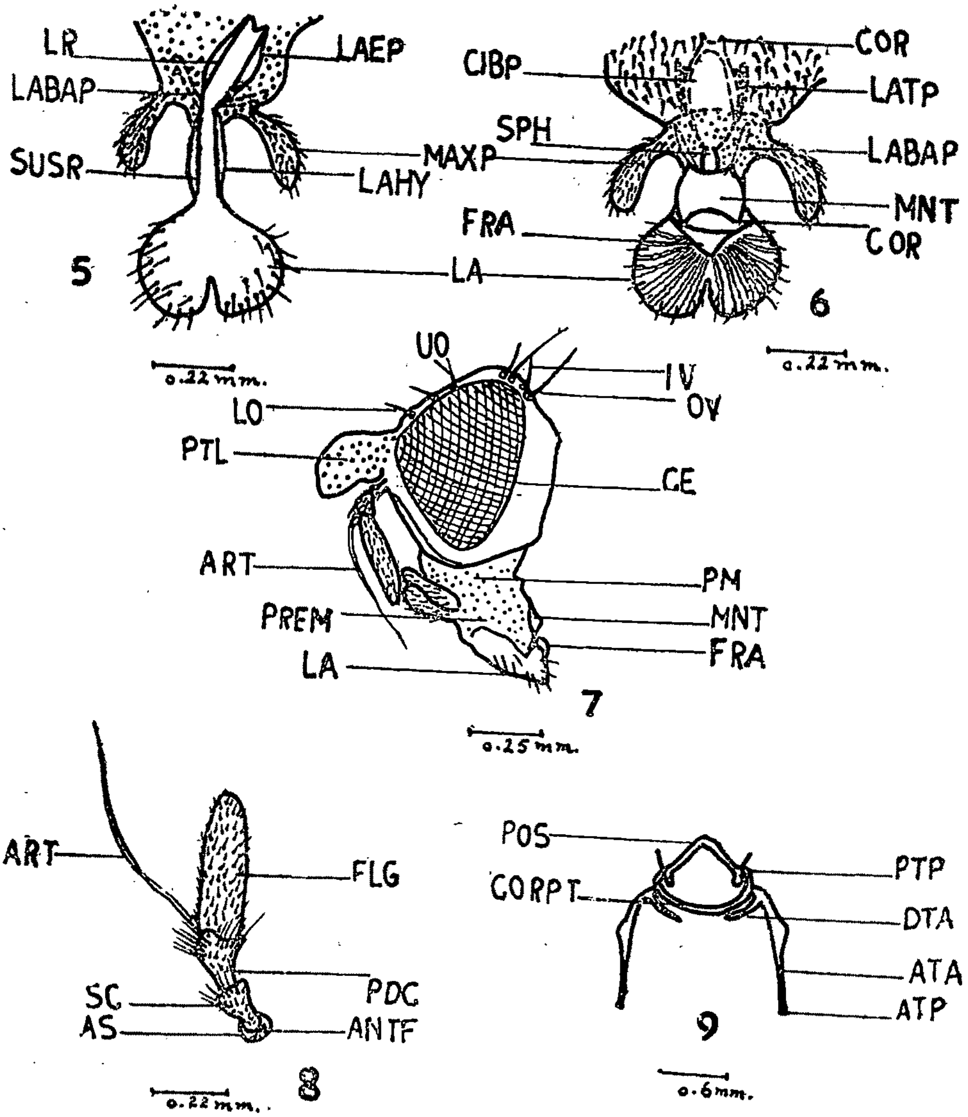


4

1. Head (female) - Dorsal view with proboscis.
2. Head (male) - Ventral view with proboscis.
3. Head (male) - Dorsal view without proboscis.
4. Head (female) - Ventral view without proboscis.

As. Antennal socket; *Ata.* Anterior tentorial arm; *Atp.* Anterior tentorial pit; *Art.* Arista; *Ce.* Compound eye; *Cibp.* Cibarial pump; *Cly.* Clypeus; *Corpt.* Corpotentorium; *Dta.* Dorsal tentorial arm; *Fra.* Furca; *Gb.* Gular bristle; *Ge.* gena; *Hyb.* Hypostomal bridge; *IV.* Inner vertical; *La.* Labella; *Laep.* Labrum-epipharynx; *Lo.* Lower orbital; *Loc.* Lateral ocellus; *Lu.* Lunule; *Maxp.* Maxillary palp; *Mnt.* Mentum; *Moc.* Median ocellus; *Ob.* Occipital bristles; *Occ.* Occipital condyle; *Occf.* Occipital foramen; *Ocp.* Occiput; *Ov.* Outer vertical; *Pg.* Post-genals; *Pge.* Post-gena; *Po.* Post-orbital; *Pocp.* Post-occiput; *Pof.* Postfrons; *Pos.* Post-occipital suture; *Pref.* Pre-frons; *Pseut.* Pseudotracheae; *Ptp.* Posterior tentorial pit; *Pts.* Ptilinal suture; *Tps.* Temporal suture; *Uo.* Upper orbital; *Vtx.* Vertex.



Figs. 5-9

5. Proboscis - Dorsal view with the labrum epipharynx turned upwards.
6. Proboscis - Ventral view.
7. Head - Lateral view.
8. Antenna
9. Tentorium

Antf. Antennifer; *Art.* Arista; *As.* Antennal socket; *Ata.* Anterior tentorial arm; *Atp.* Anterior tentorial pit; *Ce.* Compound eye; *Cibp.* Cibarial pump; *Cor.* Cornua; *Corpt.* Corpotentorium; *Dta.* Dorsal tentorial arm; *Flg.* Flagellum; *Fra.* Furca; *IV.* Inner vertical; *La.* Labella; *Labap.* Labral apodeme; *Laep.* Labrum-epipharynx; *Lahy.* Labium hypopharynx; *Latp.* Lateral plate; *Lo.* Lower orbital; *Lr.* Longitudinal ridge; *Maxp.* Maxillary palp; *Mnt.* Mentum; *Ov.* Outer vertical; *Pdc.* Pedicle; *Pm.* Postmentum; *Pos.* Post-occipital suture; *Prem.* Pre-mentum; *Ptl.* Ptilinal suture; *Sc.* Scape; *Sph.* Siphon; *Susr.* Suspensorial rod; *Uo.* Upper orbital.

SOME OBSERVATIONS ON THE GENITALIA OF *DACUS DIVERSUS* COQ. (TRYPETIDAE: DIPTERA)*

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I. Introduction
II. Material and Method
III. Male Genitalia
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Introduction

Relatively little work seems to have been done on the genitalia of Trypetidae. Miyake (1919) was perhaps the first to stress the importance of the structure of genitalia in Trypetidae. Benjamin (1934) described some of the North American Trypetid flies illustrating the ninth terga only. Hanna (1939) studied the structure and operation of the reproductive organs of the Mediterranean fruitfly. Munro (1947) described the genitalia of African Trypetidae in detail and compared them with the genitalia of *Calliphora.* No work has so far been done on the genitalia of Indian Trypetidae. This paper deals with the structure of the genitalia of *Dacus diversus* Coq.

Material and Method

The adult flies, collected from *Luffa aegyptiaca* Mill. in Hoshiarpur, Punjab, were treated with 10% cold KOH for 24 hours, neutralised in acetic acid, upgraded and preserved in glycerine. The diagrams were drawn with the help of a graph eye-piece. The terminology followed here is based on that of Munro (1947).

The Male Genitalia

The male genitalia are constituted by the ninth segment of the abdomen. They are hidden below the fifth tergum, which is produced behind into a tapering plate. Miyake (1919) has reported that they are concealed by the

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notum of the seventh segment in *D. tsuneonis*. The ninth tergum (T9) is highly sclerotised and rounded in outline, with a posterior membranous proctiger (PTR). Anteriorly its lateral walls are modified into two lateral curved and pointed processes, called surstyli, (SURS). Near the base of each of surstylus, there lies a small black, claw-like structure (CLW) called the outer clasper by Munro (1947). This is perhaps comparable to the gonostyles in other orders. These appear to be tactile or prehensile or both in function. Minute setae are present on the outer claspers. Anterior to the ninth segment is the complicated part of the male genitalia, formed of an oval ring, called the genital ring (GR), the transverse piece, the fultella (FULT), the sclerotic process, the phallic apodeme or ejeculatory apodeme (EJEAP) and a long coiled tube the phallotheca (PHT). The genital ring is placed horizontally and most probably represents the sternum of the ninth segment. The fultella is a transverse bar, attached anteriorly to the genital ring, and giving out two lateral processes, which hang on the latter. These processes are called the vanes by Munro (1947). At the point of attachment of the fultella is present on the left side a sclerotic structure, called the ejeculatory apodeme or the phallic apodeme. Just near the base of fultella on the right side comes a long coiled tube from the ring called the phallotheca, which is pierced by seminal duct throughout its length. The outer surface of the phallotheca is smooth. Near the tip of the phallotheca there is a constriction, marking the beginning of aedeagus, which is broad at its base and ends in a terminal spine-like process.

FEMALE GENITALIA

The last three segments of the abdomen constitute the so called 'ovipositor', a telescopic tube for the deposition of the eggs. Snodgrass (1935) describes this type of ovipositor as the substitutional 'ovipositor'.

The ovipositor is greatly elongated in the stretched out condition, otherwise it lies telescoped in the oviscape (OVS) or the seventh segment. According to Munro (1947), it consists of three parts (i) the oviscape, (ii) the inversion membrane (IM) and (iii) the aculeus (ALS). The first part or the base of the ovipositor or the oviscape is the modified seventh abdominal segment, having a pair of spiracles corresponding to the seventh pair of abdominal spiracles (S7). This part constitutes the major portion of the ovipositor and is the result of the longitudinal fusion of the sternum and the tergum of the seventh segment. This tube is flattened at the base only and has a more or less uniform bore upto its terminal end. It bears minute bristles all along its lateral walls. On the ventral side, a valve (VLV) is present below the sixth sternum, which marks the beginning of the oviscape. Next to the oviscape is the second part of the ovipositor or the inversion membrane, which is membranous and thus clearly marked from the oviscape. It is nearly one-fourth the former. It is devoid of any bristles on its surface or the lateral walls and represents eighth abdominal segment, though the eighth pair of abdominal spiracles are not present. Aculeus or the piercer or the sting is the third and the terminal part of the ovipositor, which is pointed at its tip and is used in piercing the epidermis of fruits in egg laying. This may represent the ninth or also the tenth and eleventh segments of the abdomen. The tip of aculeus has the opening for the passage of the eggs.

SUMMARY

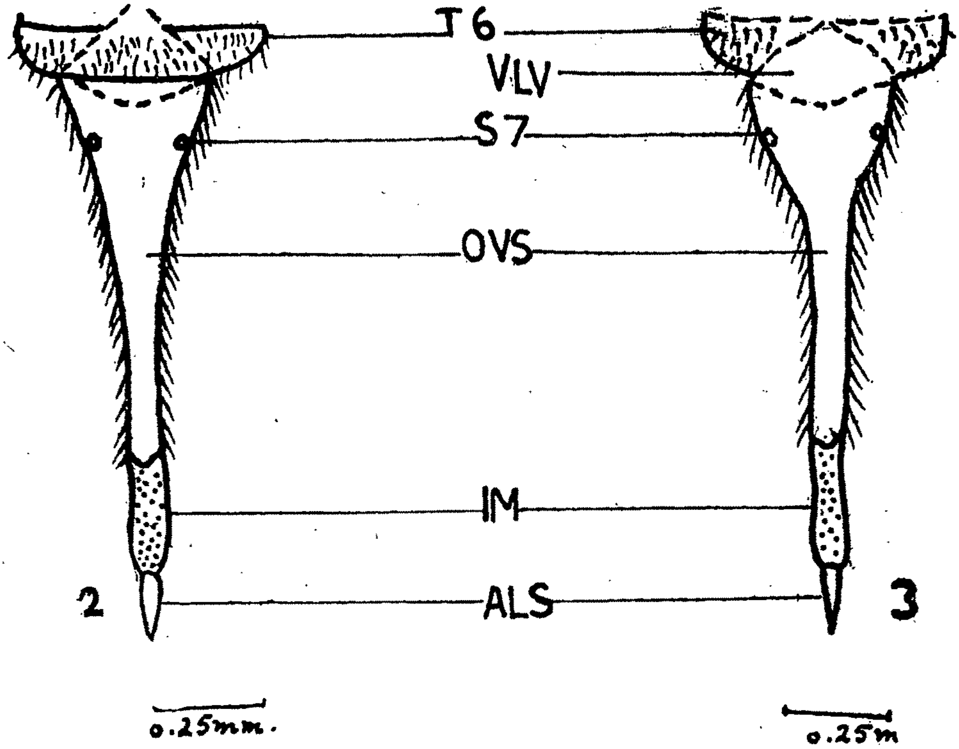
The male genitalia are the modified ninth abdominal segment, and comprise the genital ring, the fultella, the ejeculatory apodeme and the phallotheca alongwith aedeagus. The female genitalia or the substitutional 'ovipositor' represents the modified seventh, eighth and ninth abdominal segments and are called respectively the oviscape, the inversion membrane and aculeus.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. T. Singh, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra for his valuable guidance and facilities for work. My sincere thanks are due to Dr. G. L. Arora, Reader in Entomology, Department of Zoology, Panjab University, Chandigarh, for suggesting the problem and necessary help.

REFERENCES

1. Benjamin, F.H. 1934. Description of the native Trypetidae with notes on their habits. *Tech. Bull. U.S. Dept. Agri.*, Washington, D. C. No. 401.
2. Hanna, A.D. 1939. Studies on the Mediterranean fruitfly *Ceratitis capitata*. Wied. The study and structure of reproductive organs. *Bull. Soc. Fouadler. Ent. Cairo*, **22** : 39.
3. Miyake, T. 1919. Studies on the fruit-flies of Japan. Bulletin of the Imperial Central Agricultural Experiment Station in Japan, **2**, (2)
4. Munro, H. K. 1947. Memoirs of the Entomological Soc. of Southern Africa. African Trypitidae (Diptera) Published by the Soc. P. O. Box 103, Pretoria Union of South Africa, No. **1**.
5. Snodgrass, R. E. 1935. Principles of Insect Morphology. Mc Graw-Hill Book; Co., New York and London.


T6
VLV
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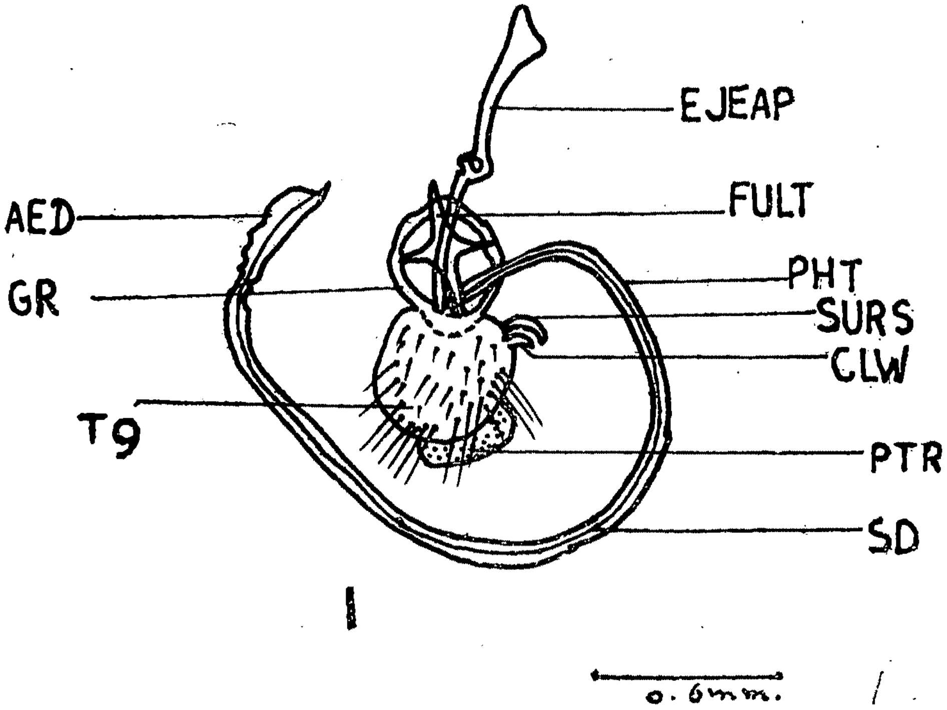
EJEAP
AED
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SURS
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T9
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SD
1
0.6mm.

Figs. 1-3.

1. Male genitalia.
2. Ovipositor—Dorsal view.
3. Ovipositor—Ventral view.

AED. Aedeagus; *ALS.* Aculeus; *CLW.* Claw;
EJEAP. Ejeculatory apodeme; *FULT.* Fultella;
GR. Genital ring; *IM.* Inversion membrane; *OVS.* Oviscape;
PHT. Phallotheca; *PTR.* Proctiger; *S7.* Seventh abdominal spiracle; *SD.* Seminal duct; *SURS.* Surstylus; *T6.* Sixth tergum; *T9.* Ninth tergum; *VLV.* Valve.

PARTHENOCARPIC DEVELOPMENT OF FRUIT FOLLOWING AN INTERSPECIFIC HYBRIDIZATION. (CROTALARIA JUNCEA X CROTALARIA INTERMEDIA).

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As early as 1901 Millardet reported that the fruits of European grapes could be induced to grow parthenocarpically by pollinating them with foreign pollen grains. There are now a number of cases on record where parthenocarpic development of fruit has been observed following natural or artificial crossing (Gustafson, 1937, 1939 ; Maheshwari, 1940 ; Yasuda, 1939). It has has been suggested by Laiback (1932, 33) and Yasuda (1930,33,34,39) that pollen has a definite influence on the growth of the ovary, which is independent of the process of fertilization. Thus parthenocarpic fruits can develop if the stimulus of pollination only is provided. The present author, during crossing experiments in *Crotalaria* species, came across unilateral parthenocarpic development of fruits which is described here.

The seeds of *Crotalaria intermedia* (E. C. 7476) and *C. juncea* obtained from I. A. R. I. and Local stock respectively, were sown in June in the College Botanic Gardens. Hand emasculation of the flower buds was done in the morning before the dehiscence of anthers, immediately followed by pollination and covering under butter paper bag. The reciprocal crosses, using each of the species as female parent, were made. For the study of the germination of the pollen grains on the stigma and the growth of the pollen tubes in the style, the pistils were fixed in F. A. A. or alcohol-acetic acid (3 : 1) after 24, 48 and 72 hours of pollination. The fixed pistils were preserved in 70% alcohol. These were softened in hot acqeous solution of KoH and then cleared in lactic acid. The pistils were stained separately in safranin for three or four hours and then in anilin blue in absolute alcohol or in a Safranin-Anilin Blue combination after Dionne and Spicer (1958). The stained pistils were dissected under a binocular microscope to show the pollen tubes, and after dehydration through alcohol and xylol grades, were mounted in Canada Balsam.

Crotalaria juncea differs morphologically from *Crotalaria intermedia* (E. C. 7476) in having unifoliate simple leaves with acute apex and hairy surface. Its stem is also hairy and angular. The flowers are typically papilionaceous. The style is hollow and forms a 146° angle with the ovary. The *Crotalaria intermedia* has trifoliate leaves, with acute apex and glabrous surface. The stem is smooth and round. The angle of the style with the ovary is 132°. The style is hollow but unlike *C. juncea* the style and stigma are not hairy.

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When flowers of *Crotalaria intermedia* are pollinated with *C. juncea*, most of the ovaries (about 75%) start withering 3-4 days after pollination through the formation of an abscission layer in the *pedicel of flower*, and finally fall off. Only a few ovaries remain attached for as long as a month (Fig. 1). These ovaries, though seem to develop normally like self pollinated, ones, are completely devoid of seeds (Fig. 2). A probe into the causes of the failure of seed development reveals that the pollen tubes from *Crotalaria juncea* pollens are unable to reach the ovules of *C. intermedia* and effect fertilization. The ovules are aborted without any further development and the fruit develops parthenocarpically.

In reciprocal crosses, when *C. juncea* is used as female parent, all the ovaries drop off within 5 to 6 days following cross pollination after showing only a very feeble growth.

In both the crosses the germination of pollen grains on the stigma and cosiderable growth of the pollen tube in the style was observed. Pollen grain of *C. juncea* germinated very quickly on the stigma of *C. intermedia* and the pollen tubes were seen entering the stylar canal within 24 hours of pollination. These pollen tubes showed the formation of callus pads soon after they had penetrated through the stigma (Fig. 3). The pollen tubes traversed through half the length of the style after 48 hours of pollination, while in some cases they even entered the ovary cavity. In the material fixed after 72 hours of pollination no further progress of the pollen tubes could be made out.

In reciprocal cross, the pollen grains of *C. intermedia* germinated well on the stigma of *C. juncea* and the pollen tubes travelled through 1/3 length of the style within 24 hours of pollination. In the material fixed even after 72 hours of pollination no further growth of the pollen tube could be observed.

These interspecific crosses show unilateral parthenocarpic development of fruit, which seems to be correlated with the pollen tube development. It appears that the stimulus received by the ovaries of *C. intermedia* from the pollen tubes of *C. juncea* (which are able to reach upto the ovary cavity) seems to be sufficient to promote the parthenocarpic growth of the fruit. In the reciprocal crosses where the pollen tubes from *C. intermedia* pollens do not reach the ovary of *C. juncea*, no parthenocarpic development of the fruit was observed. It is generally believed that mere pollination, without any subsequent pollen tube growth, may be enough to induce parthenocarpy (Yasuda, 1939). Therefore, the failure of parthenocarpic development of the fruit in *C. juncea*, may not actually lie in the arrested development of *C. intermedia* pollen tubes in the pistils of *C. juncea*. Gustafson (1942) appears to provide a plausible explanation for this. He says : "Some plants under some conditions produce enough growth hormone so that with or without pollination, as the case may be, they are able to prevent the absciss layer from being formed in the pedicel ; and that under favourable nutritive conditions and with a minimum of competition, they are further able to transport the necessary food and bring about enlargement of the cells in the ovary to produce mature fruits without seeds, whereas other plants are unable to do this." The present case of unilateral parthenocarpic development of fruits in the crosses between *C. intermedia* and *C. juncea* proves Gustafson view point. *C. juncea* plants seem to be unable to carry out the necessary transport of the food material and bring about the enlargement of the cells in the ovaries necessary for the development of the fruit in the absence of fertilization, while *C. intermedia* can.

ACKNOWLEDGEMENTS

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REFERENCES

1. Dionne, L. A. and Spicer, P. B. 1958. Staining germinating pollen and pollen tube. Stain Tech. **33** : 15-17.
2. Gustafson, F. G. 1937. Parthenocarpy induced by pollen extracts. *Amer. Jour. Bot.* **24** : 102-107.
3. Gustafson, F. G. 1939. The cause of natural parthenocarpy. *Amer. Jour. Bot.* **26** : 135-138.
4. Gustafson, F. G. 1942. Parthenocarpy : Natural and Artificial. *Bot. Rev.* **8** : 599-654.
5. Laibach, F. 1932. Pollenhormone und wuchsctoff. *Ber. : deutschhot. Gessel.* **50** : 383-390.
6. Laibach, F. 1933. Versuche mit wuchsstoff paste. *Ber. deutschhot. Gessel.* **51** : 386-392.
7. Maheshwari, P. 1940. The role of growth hormones in the production of seedless fruits. *Sci.* and *Cult.* **6** : 85-89.
8. Millardet, A. 1901. Rev. de Vitie. **16** : 677-680.
9. Yasuda, S. 1930. Parthenocarpy caused by the stimulation of pollination in some plants of Solanaceae. *Agri. and Hort,* (Tokyo) **5** : 287-294.
10. Yasuda, S. 1933. On the behaviour of pollen tubes in the production of seedless fruits caused by interspecific pollination. *Jap. Jour. Gene.* **8** : 239-244.

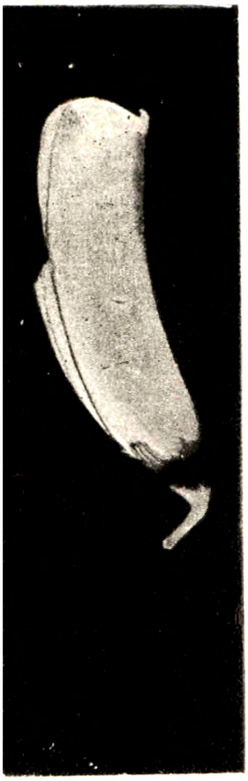

FIG. 1.

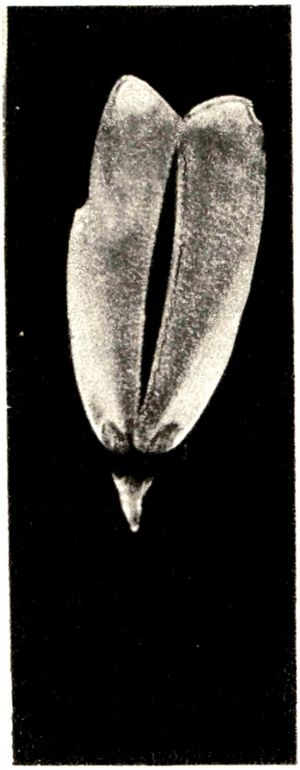

FIG. 2.

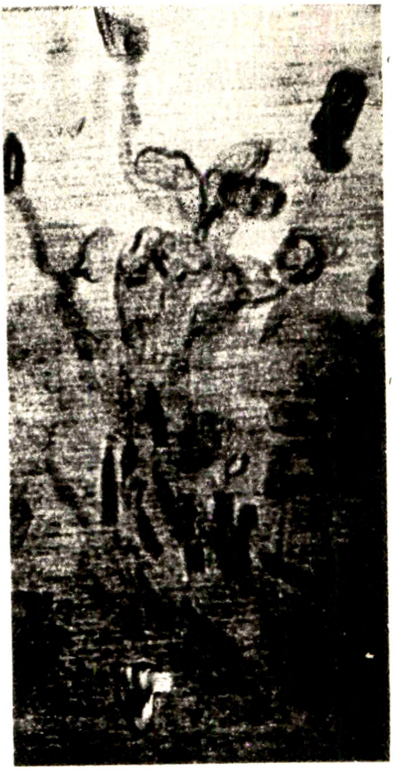

FIG. 3.

Fig. 1. Side view of one month old seedless fruit of *Crotalaria intermedia.*

Fig. 2. *Crotalaria intermedia* fruit showing the degenerated ovules.

Fig. 3. *Crotalaria intermedia* stigma showing the germinated pollen garins of *C. juncea* after 48 hours of cross pollination. The dark portions of the pollen tubesare due to callus pads.

VELOCITY OF FLOW OF ORGANIC LIQUIDS THROUGH ADSORBENT COLUMNS IN THE ASPECT OF THEIR STRUCTURE*

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The velocity of flow of liquids through a packed column is a particular aspect of the flow of homogeneous fluids through a porous medium. In any column made of suitable adsorbent like silica, alumina, fuller's earth etc. there are a large number of voids which form the pores through which the liquid can flow or permeate with a certain velocity. These pores are arranged under packed condition in such a way as to form an interconnected network of channels which allow the liquids to form the stream of flow. The same is true for all porous bodies and the underground layers of the soil where the degree of compactness may vary from medium to medium according to the physical conditions of their formation. The engineers are frequently faced with specific problems of underground filters, petroleum beds and water seepage, but they have their own limitations to solve such difficulties as involve the role of surface forces and structure of the liquid molecules. Mathematical equations, based on hydrodynamics, porosity and the geometrical shapes of the particles and passages, do not cover up all the factors which ultimately govern the velocity of flow of liquids through any porous medium. Such limitations of purely mathematical or physical treatments of the phenomenon necessitate further study of the problem with a physico-chemical bias to elicit adequate information on the influence of the structures of the liquid molecules and also of the solid particles, when the liquids flow through the pores of a column. While the existing ideas regarding the capillary flow of liquids are mainly centred round the dynamic and porosity factors, the role of the physico-chemical forces operating in such systems does not seem to be less important. In order to bring out the evidences of the role of molecular structure on the velocity of flow of liquids through the porous columns the need of extensive investigations under controlled conditions of the height of the column, pressure, temperature, size and shape of the particles cannot be overemphasized.

The earliest reference to the quantitative study of the rate of flow through a porous column is found in the classical work of Henry Darcy[5] in 1856 whereby he established that the rate of flow of water through a column of sand could be expressed by the equation $Q = K. A. \frac{h}{l}$, where h was the height of sand column or length of path, A was the area of the corss section, h was the drop in manometer height, and K was the proportionality factor called the permeability coefficient. This relationship soon became known as Darcy's Law and subsequently many attempts were made to give this simple empirical expression a more elaborate significance by including such other properties of the liquid as govern the velocity of flow through the porous columns. Slichter[10] in 1897, Smith and Co-workers[11] in 1929, Grayton and Fraser[6] in 1935 made extensive studies on porosity and permeability under different modes of packing the columns with different size grades of particles. Slichter observed that permeability was proportional to the square of the radius, R, assuming that the particles were spherical. But Fancher, Lewis and Barnes[9] in 1933 investigated the same problem and observed that the proportionality between permeability and R^2 did not hold good in many cases. From these observations it was concluded that the particles were not spherical in all cases as had been assumed by Slichter and that the porosity, and shape of the pore spaces may be considerably affected by the size, shape and arrangement of the particles and these factors would ultimately change the permeability of the porous column.

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The above conclusion seems to be only partially correct. In this connection results of a series of experiments published by Bhattacharya and Gupta[3] brought out a clear evidence of the fact that the velocity of flow not only depended upon the porosity and shape of the pore spaces due to the size and shape of the particles, but also on the characteristic surface forces of the material. In order to verify this fact, the size of the particles was graded between 60-80 mesh, 80-100 mesh and 100-120 mesh by successive sieving through the standard sieves. It was strikingly observed that, other conditions being kept equal, the rate of flow was slightly increased with the fineness of gradings. If porosity and pore spaces due to the size and shape of particles were the only factors, the velocity of flow of the same liquid should remain the same to the nearest approximation for columns of the same size gradings of different substances, like SiO_2, Al_2O_3 and MgO etc. But the observed rate of flow was different for columns prepared with different materials. The order of velocity, however, supported the fact that decrease in the size grades probably increased the porosity of the system which might have been responsible for the slight increase in the rate of flow. But since the velocity was different for different adsorbents, it was evidenced that porosity and surface characteristics both had their combined effect on the flow of liquids. Porosity is a measure of the fluid bearing capacity, while permeability is a measure of the ease with which the fluids may traverse the medium. Thus it can be visualised that the ease of flow may depend not only on the fluid capacity and the pressure, but also on how the surface properties react on the fluid and *vice versa*. Such effects like swelling and hydration are the well known phenomenon which affect the liquid carrying capacity; hence it need not be too strongly emphasized that suitable modifications in the existing theory of flow are necessary to co-ordinate the dynamic factors with the surface forces and chemical structure of molecules. Due to the existence of such undefined forces the hydrodynamical equations do not give a satisfactory solution.

Slichter[10] formulated another equation for the quantitative study of the flow of ground water which was expressed as $Q=10{\cdot}22\frac{Pd^2S}{\mu hk}$, where P was the defference of pressure, d, the mean diameter of the particles, S, the cross sectional area, h, the height of the column, μ the coefficient of viscosity and k was a constant. In this equation Slichter recognized that the viscosity of the liquid is an important physical property to be considered along with the other variables in determining the flow of liquids.

In 1933 Zunker[13] gave a complicated equation for the quantitative study of the flow of water which was expressed as $Q=\frac{\mu h.}{lu^2\eta}\left(\frac{Po}{1-P}\right).F$, where Q was the amount of transmitted water, h, the pressure difference η, the coefficient of viscosity; l, the length of the column and F the cross sectional area. He also brought in a number of other factors such as (i) the number of free pore spaces (P_o), (ii) total number of pore spaces (P), (iii) the effective surface (μ); and (iv) a factor for the arrangement of particles (μ). In this formula, Zunker seems to be the first to recognize that the surface of the medium plays its effective role in the flow of liquids through a porous column, but it was difficult to verify his equation due to the lack of adequate techniques.

In 1942 Le Rosen[8] visualised that every solvent used in chromatography should have its flow characteristics which would depend upon the nature of the adsorbent column. On this assumption he made an ingenious approach to standardise the various adsorbents by evaluating a number of terms which were characteristic of the column and also of the solvents. The standardisation of the adsorbent column depended on the values of (i) the constant velocity of flow of the solvent, Vc, (ii) a number S for the average packing and (iii) the velocity of the movement of the adsorptive zone relative to that of the solvent expressed as R. These observations of Le Rosen in the technique of chromatography are strongly suggestive of some kind of interaction between the solvent and surface forces in the column to give a constant velocity, Vc, characteristic of the adsorbent column. Such observations of Le Rosen lead to the corollary that, if the pressure, height of the column and size grade of the particles are fixed, the rate of flow will depend upon the structural characteristics of the liquid and of the surface.

Hardy, Langmuir, Harkins and Adam's investigations on the spreading of liquids and formation of surface films furnished definite evidence of the orientation of long chain molecules due to polar interactions. The formation of uni- and multimolecular films at the contact surface of liquids was another interesting feature to support the existence of the forces of attraction at the interface. Harkins and Jura[7] in 1944 observed further that the films are also formed at the solid-liquid interface. Titanium dioxide-water interface is an interesting example where films of measurable thickness are formed. The thickness of the films was found to vary from liquid to liquid. They observed that at O°C the thickness of the film at the interface of titanium dioxide and butane was 64A°, and it was suggested by them that the butane molecules lie flat on the surface. In some cases, characteristic aggregation or dispersion of solid particles also takes place in particular liquids. This has been observed in the behaviour of calcium carbonate when it is stirred in a polar or non-polar liquid. In benzine, xylene, cyclohexane, the particles of calcium cabonate form spongy clots, while in methyl and ethyl alcohol they become highly dispersed. Such properties of aggregation or dispersion in a particular liquid undoubtedly changes the structure of the medium. Hence the velocities of flow of benzene, toluene, xylene, and cyclohexane were found to be greater than the alcohols due to the specific types of the structural aggregates of the particles.[3]

Swelling and shrinkage[2] is another remarkable property which we often come across in the behaviour of clays and some typical soils like the black cotton soil. Water logging in many areas is not an uncommon experience which arises from the low permeability and percolation. This kind of phenomenon is directly connected with soil structure and the properties of colloidal clay which are characterised by the surface forces of the system. The swelling phenomenon depends upon hydration of clay particles and on the common property of a large existing surface or potential surface and several other physico-chemical properties of the swelling solids as well as of the liquid. The existence of different kinds of swelling has been proved by X-ray spectrography. The foregoing observations on the swelling of clays and other adsorbents lend a strong support to the proposition that the rate of flow through an adsorbent column is not only a function of the dynamic variables but also of the undefined surface forces, molecular orientation, and structure of liquid molecules.

Bigello[4] (1907) and Bartell[1] (1911) reported some interesting observations on the diffussion of ions and neutral molecules through the semipermeable membrane of copper ferrocyanide. They observed that the rate of diffusion of some salts was proportional to the adsorption of negative ions. Weiser[12] (1930) made an extensive study of the permeability of ions through the pores of copper ferro and ferricyanide membranes and observed that the chloride, sulphate, and ferricyanide ions passed freely through the pores of these membranes but the ferrocyanide ions were held up in the pores. It was difficult to explain why some ions can diffuse readily, while some others are held up within the pores or diffuse very slowly. In order to explain such an anomalous behaviour of ions Weiser postulated that the diffusion of ions through the pores of the membrane was, a priori, influenced by the strong or weak forces of adsorption. He suggested that the force of adsorption with ferrocyanide ions was much stronger than with the chloride, sulphate and the ferricyanide ions, and this resulted in the clogging of the pores by the ferrocyanide chains which extended from the surface downward into the pores of the memrane. He visualised further that the chains of the ferrocyanide formed the barrier of a film which was responsible for the anomalous behaviour of ferrocyanide ions. Bhattacharya and Malik[3(a)] in their studies on the diffusion of ions through the ferrocyanide membranes determined the relative values of adsorption which qualitatively supported the view of Wieser regarding the ionic adsorbability and their diffusion through the semi-permeable membranes. These observations on the diffusibility of ions through the ferrocyanide membranes may not be strictly applicable to the flow of liquids through the porous adsorbent columns, yet the observations of Weiser are of significant importance in the study of the physico-chemical forces which interfere with the normal dynamic laws of flow in the different types of porous bodies.

Bhattacharya and Gupta[3] visualised that, if the pressure, average size of particles, height of the adsorbent column and the cross sectional area were fixed, the specific effect of the surface property and structure of the liquids, if any, would be reflected in the variations of the velocity or rate of flow. The simple technique which they developed to study this aspect has been described in an earlier communication[3] (J. I. C. S. 1953, 30, 661).

Bhattacharya and Gupta[3] empirically developed an equation which gave a very significant constant, K, which was dependent on the functional group of the liquid molecules, when the values of K were determined under constant conditions of the height of the column, pressure, cross sectional area and average size of the grains. By plotting the rate of flow (v/t) against the inverse of the height of the column (1/h) the curve was linear upto an optimum value of h, similarly, when vh/t was plotted against density (d)/viscosity (η), a straight line was obtained assuming a simple proportionality among these variables, a very simple relation is derived which they have expressed as $\frac{vh}{t} \cdot \frac{\eta}{d} = K$, where K is a proportionality constant which is related to the structural characteristics of the liquid and the surface of the adsorbent. The values of K determined for the members of a certain family of organic liquids passing through the same adsorbent column surprisingly suggest that K depends on the functional group of the molecules belonging to the homologous family.

It may be mentioned here again that according to Darcy the rate of flow was dependent on the pressure gradient and viscosity, while Slichter worked out the proportionality between square of the mean diameter, R of the particles and the rate of flow. According to their equations the velocity of flow of a liquid should remain the same when it flows through different porous columns having the same mean diameter of particles under the same pressure. If the flow depended only on the pressure, diameter of particles, and the viscosity of the liquid, the rate of flow for the same liquid should be independent of the nature of the material of the column under equal conditions of pressure and mean diameter of the particles. But the results of Bhattacharya and Gupta[3] showed that the velocity of flow also depended upon the nature of the adsorbents when the same liquid flowed through their columns under constant physical conditions. The figures obtained for the rate of flow of water when it passed through different columns were for calcium carbonate (.0036), silicic acid (.0069), fuller's earth (.0013), Kieselguhr (.011) and magnesium oxide (.009). According to these figures the above adsorbents may be arranged in the order of their water transmission capacity as kieselguhr >magnesium oxide> silicic acid> calcium carbonate> fuller's earth. Similar results were obtained for alcohols, esters, ketones and aromatic hydrocarbons where the rate of flow of the liquid and the order of the liquid transmission capacity were found to be specific with the nature of the liquid and the adsorbent column. The foregoing observations obtained under fixed conditions of pressure and mean diameter of particles were very significant to suggest that the variations in the rate of flow must be due to the changes in the size and shape of the pores and capillaries which depend on the nature of the liquid and solid. In all probability, the interfacial forces between the liquid and the surface of the particles of the adsorbent are responsible for the specific sizing and shaping of the pores in the column.

The velocities of flow (v/t) were determined for benzene, methylacetate, acetone, water and methyl alcohol by passing them through the columns of silicic acid, kieselguhr, calcium carbonate, fuller's earth, magnesium oxide, alumina and calcium hydroxide. The order of liquid transmission gave interesting evidences to show the importance of surface properties and liquid structure. Through the silicic acid and kieselguhr columns the velocity of transmission followed the order C_6H_6>MeAc>Acetone>water>MeOH. This similarity of the order was in all probability due to the geometrically similar pores and passage of the two systems ; or, in other words, this may be ascribed to the supposed similarity of surface characteristics of silicic acid and kieselguhr. The order of flow through the calcium carbonate column was C_6H_6>Acetone>Me Ac> Water>MeOH ; for fuller's earth, it was MeAc>C_6H_6>acetone>MeOH>water ; and with magnesium oxide, it was MeAc>Acetone>C_6H_6>water>MeOH. The foregoing orders of liquid tranmissions through different adsorbent columns suggest that the pore factors of these adsorbent columns are appreciably affected by the interfacial forces between the adsorbent and the liquid. Benzene has the highest relative flow through silicic acid, kieselguhr and calcium carbonate, but this is not the case with fuller's earth, and magnesium oxide. The order of flow of water and methyl alcohol is similar in silicic acid, kieselguhr, calcium carbonate and magnesium oxide, but it is not so in the case of fuller's earth. Similar reverses are observed in the relative order of flow of benzene, methyl acetate and acetone by changing the adsorbent columns. These observations are very pertinent to warrant the fact that the surface and structural characteristics play a very important role in the flow of liquids through the porous columns. Another striking observation was that the non-polar liquids in general could pass through the porous columns more quickly than the polar ones. Benzene, for example, which is non-polar, had a greater rate of flow through the columns of silicic acid, keiselguhr, fuller's earth, calcium carbonate and magnesium oxide than the velocity of transmission of the polar molecules of water and methyl alcohol.

The role of the functional group or groups in the liquid molecules was very remarkably shown by the values of K evaluated from the equation, $\frac{vh}{t} \cdot \frac{\eta}{d} = K$. It provided a positive evidence of the fact that there is some specific relation between the velocity of flow, η and d of liquids and the characteristic functional group of a family of organic compounds. Under the constant condition of the known variables, K was found to be constant for a particular family like alcohols or ketones or esters etc. Each family was found to have their specific and constant value of K for the particular adsorbent, and it changed to give another constant, only when the homologous family was changed. Similar was the case when the adsorbents were changed for the same family of liquids. This leads to support the view that the structural factors and functional groups have some correlation with the rate of liquid transmission through the porous columns.

Since the volume of flow v/t per unit time varies inversely as the height of the column, the expression vh/t may be defined as the volume of liquid which passes through the unit height of the column in unit time. If this simple interpretation of the expression vh/t is admissible, its relative values enable us to compare the liquid transmission capacity of different porous columns by fixing the other variables of the system. For example, the relative values of vh/t of different families through silicic acid and calcium hydroxide columns are 1 : 1·58 (alcohols), 1 : 2·9 (esters), 1 : 3·7 (Ketones) and 1 : 2·01 (aromatic hydrocarbons). These figures clearly indicate that the calcium hydroxide column is more porous than silicic acid and the porosity as well as the shape and size of the pores differ according to the family of organic liquids which are made to flow through the adsorbents. When the fluid and suction pressure, size of grains and temperature are fixed and packing of grains are assumed to be uniform, the only other variables which may alter the rate of flow are the porosity, size and shape of the pores in the column. These differences in the rates of transmissions through different columns can, therefore, be only attributed to the inter-facial forces which ultimately depend upon the polarity and structure of the liquid molecules and the particles of the column.

The important role of functional groups on the flow of organic liquids was further evidenced by taking mixtures of organic liquids belonging to the same family. In view of the complexities which generally arise in the viscosities of mixed liquids, it is difficult to anticipate that mixed members of the same family would give the same value of the constant K as that of the pure components. Nonetheless, the experimental results showed that the values of the constant 'K' for the mixtures of methyl-ethyl, methyl-propyl, methyl-butyl, methyl-amyl, and propyl-butyl alcohols were the same as the constant calculated for the homologues of the alcohol family. Similar results were also obtained for the mixtures of esters, ketones and the aromatic hydrocarbons. These observations again give a reassuring evidence of the part played by the functional group in the transmission of liquids through adsorbent columns.

A more interesting evidence of the dependence of the velocity of flow on the structure of liquid molecules was obtained in the behaviour of the ortho-,meta-, and para—compounds. It was observed that the velocity of flow through a particular column was appreciably altered by the group in the ortho-, meta-, and para—positions. o-meta nitrotoluenes, o-, m- and p-chlorotoluenes, o-, m-, and p— xylenes, o- and m- toluidines, o-, and m-anisidines and o-, p-phenatidines were made to flow through the packed columns of seven different adsorbents, Calcium carbonate, magnesuim oxide, alumina, fuller's earth, keiselguhr, silicic acid and animal charcoal under the controlled conditions as in other experiments and it was observed that the velocity of flow of these isomers was appreciably altered by the ortho-, meta-, and para- positions of the substituent groups. The values of vh/t suggest that there is a definite order in the ratio of flow of the o-, m- and p- liquids for all adsorbents depending on the nature of the substituents in the aromatic ring. On the basis of experimental data, the above mentioned liquids could be classified into two groups—(i) those in which the values of vh/t had the order, ortho$>$meta, as in the case of nitrotoluenes, chloroanilines, phenatidines, and anisidines, and (ii) those in which the values of vh/t had the order ortho$\angle$meta$\angle$para, as in the case of xylenes, chlorotoluenes, and toluidines. Such a regularity in the order of the flow of the isomers in all adsorbents is very significant to establish the fact that the structural properties of liquids contribute appreciably to the velocity of flow to which hardly any serious attention had been paid by the previous workers.

The available data on dipole moments of these isomers have thrown some light on the correspondence between the orders of flow and the dipole moments of ortho, meta and para liquids. In some cases the values of vh/t for the ortho-, meta- and para- liquids decrease with the increase in their dipole moments, while, in others, vh/t has been found to decrease with the decrease in the dipole moment of the isomers. No generalisation, however, can be warranted at this stage till more extensive work on the flow of substituted aromatic liquids is carried out and correct values of the dipole moments are available for all liquids.

In the equation $\frac{vh}{t} \cdot \frac{\eta}{d} = K$ it may be quite interesting to visualise the significance of K, as a structural constant like parachor or rheochor. The density (d) of the liquid being in the denominator suggests, ceteris paribus, that K is the specific constant for the flow of a family of organic liquids. Hence, if the values of K for the alcohols, esters or ketones are multiplied by the molecular weights of the ascending homologues, the products should give a constant difference due to the addition of a CH_2 group from member to member. This has been actually observed but one must be cautioned to declare a fixed value for these constants as well as for the differences of the products, because there is no method of checking up whether the arrangement of particles regulating the size and shape of the pores are identical or not. If it were so, there would have been a possibility of the emergence of a new physical constant (fluidochor?) for the liquids from their velocity of flow through the adsorbent columns.

The knowledge which has emerged out of these investigations may have larger scope of development in the proper selection of solvents by studying their flow constants in the science of chromatography. These flow constants determined under standard conditions of pressure, temperature, size grade and packing may enable us to identify the family to which a particular liquid belongs. The flow constants find their utility in characterising the nature of soils. These values may find an interesting application in the study of soil engineering to characterise the soils in terms of their permeability or percolation of ground water through the profiles. In this way, the determination of the velocity of flow may prove a very significant aspect of study in soil stabilisation for road making. If experiments are conducted on the flow characteristics of a liquid through the sedimentary rocks, the geologists may discover one more suitable index to supplement the existing ones for spotting out the organic deposits and petroleum beds wherever they exist. Thus the velocity of flow may find an important application in a number of industrial and economic problems.

The evidence for the dependence of the velocity of flow through the packed columns has also been derived from the dimensions of the proportionality constant K in Darcy's law expressed as $V=K\frac{d^2}{\eta}\cdot\frac{dp}{dx}$, where V is the volume of liquid transmitted per unit time, d the effective diameter of the grains, η the viscosity of the liquid and $\frac{dp}{dx}$ the pressure gradient. It is found that the dimension of the constant K in Darcy's equation is L^2. This immediatly suggests that Darcy did not consider the surface factor, which plays its part in the solid-liquid system, in balancing his equation. If the surface area S is put in the above equation the constant K becomes dimensionless.

Similarly in the equation $\frac{vh}{t}\cdot\frac{\eta}{d}=K$, the dimension of the constant K is L^6/T^2 which show that K represents a lumped parameter consisting of the dimensions of the gravity (L/T^3), surface (L^2) and volume of the pores (L^3) which have not been considered in balancing the equation. The equation then takes the form $\frac{V}{t} = K . \frac{I}{h} . \frac{d}{\eta} . g. S. v.$ when the constant K becomes dimensionless. Thus by dimensional inspection of the constant it has been proved that the surface property of the adsorbents or any porous medium is an important parameter to be considered in the velocity of flow of liquids. The role of molecular structure and functional groups do not come within the purview of the theory of dimensions. Evidences for such physico-chemical forces can be obtained from the thermodynamic properties of the solid-liquid interface.

REFERENCES

1. Bartell. *Jour. Phys. Chem.* 1911. **15**, 659; 1912, 659; 1912. **16**, 318.
2. Baver, L.D. *Missouri Agri. Exp. Stn. Res. bull.* 1929, 129.
3. Bhattacharya, Abani K. and Gupta. D.R.: J. I. C. S. 1953. **30**, 661; 1954. **31**, 431 1955. **32** 123; Z. Phys. Chem., 1957, **208**, 59; *Agra Univ. Jour.* 1958, **7** (ii) 113.
3. (a) Bhattacharya, Abani K. and Malik, W.U. : J.I.C.S. 1955, **32**, 501.
4. Bigellow: *Jour. Amer. Chem. Soc.* 1907, **29**, 1576, 1675; 1909, **31**, 1194.
5. Darcy, H. : "Les fontaines publiques de la ville de Dijon", 1856.
6. Graton, L. C. and Fraser, H. J.: *Jour. Geol.* 1935, **43**, 785.
7. Harkins and Jura: *Jour. Amer. Chem. Soc.* 1944, **66**, 919.
8. LeRosen : *Jour. Amer. Chem. Soc.* 1942, **64**, 1905; Anal. Chem., 1947, 19, 189.
9. Lewis, J. A. and Barnes, K. B. *Bull.* **12**, *Min. Ind. Exp. Stn. Penn. State College*, 1933.
10. Slichter. C.S.: *U.S. Survey 19th Annual Report* Part II, 295.
11. Smith, W.O. and Co-workers, *Phys. Rev.* 1919, **34**. 1271.
12. Weiser, H. B. *Jour. Phys. Chem.*, 1926, **34**, 335; Hand buch, der Bondenlehre, 1930, **6**, 66.
13. Zunker, F. Trans. 6th Comm. *Intern. Soc. Soil Sci.* (Groningen) 1933, *B*, 18.

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ACTION OF CERTAIN REAGENTS ON DIAZOKETONES

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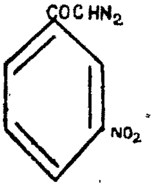
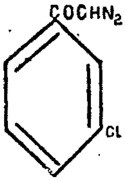
The method desrcribed by Arndt, Eistert and Partale[1] and also by Robinson and Bradley[2] has been used to prepare the following diazoketones:—

ω-diazo meta nitro acetophenone (I), ω-diazo m-chloro acetophenone, (II) α-diazo α'α'-diphenyl acetone (III) and α-diazo α'-benzyl acetone. (IV)



I



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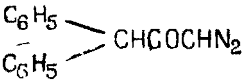


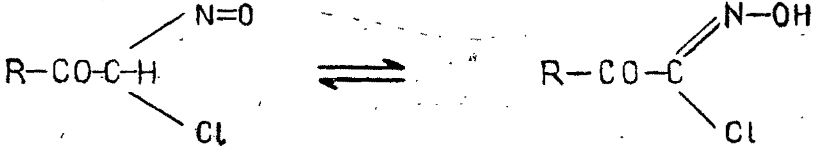
III

$C_6H_5-CH_2-CH_2-COCHN_2$

IV

The existence of the diazoketones (I, II, III and IV) was established by Arndt and Eistert Synthesis,[3] when amides of the higher homologues of the acids whose chlorides gave the diazoketones were obtained as expected by the Wolff rearrangement.[4] The amides on hydrolysis gave the corresponding acids.

U. S. Seth and S. S. Deshapande[5] found that the diazoketone $RCOCHN_2$ (V) with nitrosyl chloride gave the nitrosochloroketone (VI), which in the tautomeric form is the chloride of the corresponding hydroxamic acid (VI A). This reaction was carried out with diazoketones (I, II, III and IV) when solid nitroso-chloro ketones were obtained from I, II and III and a liquid from IV.



VI VI A

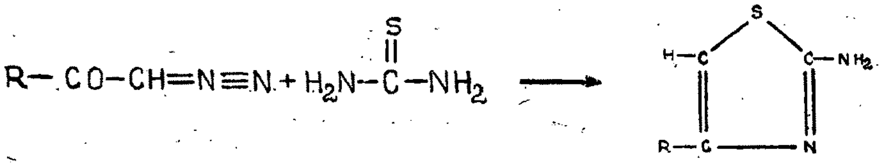
R = m-nitrophenyl, m-Chlorophenyl, diphenyl methyl phenyl-ethyl.

Concentrated hydrochloric acid in glacial acetic acid reacts with diazoketone (V) to give halomethyl ketone[6] (VII). By treating the diazoketones (I, II, III and IV) in glacial acetic acid, solid halomethyl ketones (VII) were obtained in case of I, II and III and a liquid in case of IV.

$$\underset{\mathrm{V}}{R{-}CO{-}CHN_2} + HCl \longrightarrow \underset{\mathrm{VII}}{R{-}CO{-}CH_2Cl} + N_2$$

R = m- nitro phenyl, m- Chloro phenyl, di phenyl methyl phenyl ethyl.

L. Carroll King and F. M. Miller[7] described the action of thiourea on diazoketone (V). By treating this reagent with diazoketones I, II, III and IV solid amine thiazoles (VIII) were obtained as solids in case of diazoketones, I, II and III and a liquid in case of (IV).



V VIII

R = m-nitrophenyl, m - Chlorophenyl, diphenyl methyl, phenyl ethyl.

EXPERIMENTAL

Purified acid chlorides (1 mole) dissolved in dry ether were slowly added to an ethereal solution of diazomethane (2.5 mols) at −10°C. The reaction mixture was kept at 0°C overnight. Next day on removal of the solvent under reduced pressure diazoketones were obtained. ω-Diazo meta nitro acetophenone I, ω-diazo metachloro acetophenone II and α-diazo-α'α'-diphenyl acetone III are solids while α-diazo α'-benzyl acetone IV is a liquid which could not be purified as it decomposed on distillation.

ω-Diazo meta nitro-acetophenone I.

m-Nitro benzoyl chloride (7 g., 1 mole, b.p. 100-105°C/120 mm.) gave with diazo-methane (4.4 g., 2.5 mols) ω-diazo meta-nitroacetophenone (8 g.) crystallized from alcohol m. p. 137°C. (Found N, 23.3% ; Formula $C_8H_5N_2O_3$ requires N, 22.0%). The diazoketone when subjected to Arndt and Eistert synthesis[3] gave m-nitrophenyl acetamide, crystallized from hot water m. p. 109°C (Purgotti,[8] m. p. 109-110°C). This, dissolved in hot NaOH solution and on subsequent acidification gave m-nitrophenyl acetic acid crystallized from hot water m. p. 117°C (Gabriel and Borgmann,[9] m. p. 117°C).

ω-Diazo meta chloro acetophenone II.

m-Chloro benzoyl chloride (7.5 g., 1 mole, b. p. 160°C/250 m. m.) gave with diazomethane (4.5 g., 2.5 mols.) ω-diazo m-chloro-acetophenone, crystallized from alcohol m.p. 75—76°C (found N, 14.1%, Cl, 21.1%, formula C_8H_5NOCl requires N, 15.5%, Cl, 19.7%). The diazoketone when subjected to Arndt Eistert synthesis[3] gave m-chlorophenyl acetamide m. p. 73°C (Found N, 7.6; Formula C_8H_8NOCl requires N, 8.3%). The amide when treated with 16% NaOH gave m-chlorophenyl acetic acid m. p. 76°C (S. S. Jenkins,[10] m. p. 77.5—78.5°C).

α-Diazo α'α'-diphenyl acetone III.

αα-Diphenyl acetyl chloride (8.5g, 1 mole) gave with diazomethane (3·8g, 2.5 mols), α-diazo α'α'-diphenyl acetone, crystallized from alcohol m. p. 62-63°C (L. Canorica,[11] m. p. 62-63°C), phenyl hydrazone m. p. 186-187°C (L. Canorica,[11] m. p. 186°C). The diazoketone when subjected to Arndt Eistert synthesis[3] gave ββ diphenyl propionamide crystallized from hot water m. p. 125°C (Eijkman,[12] m. p. 125-126°C (Found N, 6.0%; $C_{15}H_{15}NO$ requires N, 6.22%). The amide dissolved in alkali and on acidification gave ββ-diphenyl propionic acid m. p. 148°C.

α-Diazoα'-benzyl acetone IV.

β—Phenyl propionyl chloride (6.8g., 1 mole) b. p. 160°C/250 m. m.) gave with diazomethane (4.3g, 2·5 mols) α-diazo α'-benzyl acetone. It was a pale yellow liquid and could not be purified by distillation as it decomposed. The diazoketone when subjected to Arndt Eistert synthesis[3] gave γ-phenyl butramide, crystallized from hot water m. p. 81-83°C (Willgerodt,[13] m. p. 84·5°C).

Action of nitrosyl chloride on diazoketones (*I, II, III and IV*).

To 1 g. of the diazoketone in dry benzene at 0°C was gradually added a solution of nitrosyl chloride gas in benzene. Nitrogen was rapidly evolved. When evolution of nitrogen ceased more of nitrosyl chloride solution was added. The reaction mixture was kept at 0°C overnight. Next day on evaporation of the solvent nitroso chloroketones (hydroxamic acid chlorides) separated as solids, in case of diazoketones I, II and III while diazoketone IV gave a liquid.

ω-Chloro ω-nitroso meta nitro acetophenone (VI or VI A R=m-nitrophenyl) was crystallized from benzene m. p. 80-81°C (Found Cl. 16.2; N, 12.1; $C_8H_5N_2O_4Cl$ requires Cl, 15.7 and N 12.3 %).

ω-Chloro ω-nitroso meta chloro acetophenone (VI or VI A, R=m-chlorophenyl) was crystallized from alcohol m. p. 120°C (Found N, 6.6, Cl, 32.6; $C_8H_5NO_2Cl_2$ requires N, 6.9, Cl, 32.4%).

α-Chloro α-nitroso α'α'-diphenyl acetone (VI or VI A, R=diphenyl methyl) was crystallized from benzene m. p. 174°C (Found N, 5.5, Cl, 12·9; $C_{15}H_{12}O_2NCl$ requires N, 5.1, Cl, 13.0%).

Action of hydrogen chloride gas on diazoketones :

Dry hydrogen chloride gas was passed in 1g, of the diazoketone dissolved in glacial acetic acid at 0°C till the evolution of nitrogen ceased. After keeping overnight the reaction mixture was poured in water when solid chloro methyl ketones were obtained in case of diazoketones I, II and III and a liquid in the case of diazoketone IV.

ω-Chloro m-nitro acetophenone (VII, R=m-nitrophenyl) was crystallized from alcohol m. p. 110°C (Found Cl, 18.7: $C_8H_6O_3NCl$, requires Cl, 17.8%) Semicarbazone m. p. 195°C (Found N, 31.9%, $C_{10}H_{11}N_7O_4$ requires N, 33.4%).

ω-Chloro m-chloro acetophenone (VII, R=m-chlorophenyl) was crystallized from hot 50% alcohol m. p. 42°C (Found Cl, 36.9; $C_8H_6OCl_2$ requires Cl, 37.3%) Semicarbazone m. p. 174°C (Found N, 16.0%, Cl, 31.0%, $C_9H_9N_3OCl_2$ requires N, 17.8, Cl, 28.8%).

α-Chloro α'α'-diphenyl acetone (VII, R=diphenyl methyl) was crystallized from alcohol m. p. 71°C (Found Cl, 14.9 $C_{15}H_{13}OCl$ requires Cl, 14.5%).

Action of thiourea on diazoketones :

1g. of diazoketone dissolved in absolute alcohol was refluxed with 2 g. of thiourea for one hour. On pouring the contents in water 2-amino thiazoles were obtained as solids in the case of diazoketones I, II and III while a liquid in case of IV.

2-Amino 4-meta nitrophenyl thiazole (VIII, R=m-nitrophenyl) was crystallized from alcohol m. p. 128°C (Found N, 19.9, S, 15.0; $C_9H_7O_3N_2S$ requires N, 19.0, S, 14.5%).

2-Amino 4-m-chlorophenyl thiazole (VIII R=m-chlorophenyl) was crystallized from alcohol m. p. 137°C (Found N, 15.1, S, 15.0, $C_9H_7N_2ClS$ requires N. 13.3, S, 15·2%).

2-Amino 4-α'α'-diphenyl methyl thiazole (VIII, R=diphenyl methyl) was crystallized from alcohol m. p. 195-196°C (Found N, 11.0, S, 12.3; $C_{16}H_{14}N_2S$ requires N, 10.5, S, 12.0%).

ABSTRACT

ω-Diazo m-nitro acetophenone, ω-diazo m-chloro acetophenone, α-diazo α'α'-diphenyl acetone and α-diazo α'-benzyl acetone have been prepared by Arndt and Eistert method. Action of ammonia in presence of silver oxide, nitrosyl chloride, hydrogen chloride and thiourea has been carried out on these diazoketones and the products have been identified.

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REFERENCES

1. Arndt, Eistert and Partale; *Ber.* **60**, 1364, (1927).
2. Robinson and Bradley; *J. Chem. Soc.* **Part I**, 1310,(1928).
3. Arndt and Eistert ; *Ber.*, **68**, 204 (1935).
4. Wolff; *Ann.*, **394**, 40 (1912).
5. U. S. Seth and S. S. Deshapande; *J. I. C. S.*. **I, 29**, No. 7, (1952)
6. Wolff; *Ann*, **394**, 23 (1912)
7. L. Carroll King and F. M. Miller; *J Amm. Chem. Soc.* **71**, 367, (1949),
8. Purgotti; *Gazz. Chim ital.* **20**, 596, (1949).
9. Gabriel and Borgmann; *Ber.*, **16**, 2064, (1883).
10. S. S. Jenkins; *J. Amm. Chem. Soc.*, **55**,2896-2899, (1933),
11. L. Canorica; *Gazz. Chim. ital.*, **80**, 412-425, (1950).
12. Eijkmann; *Chemisches Zenterblatt*, **II**, 1100, (1928).
13. Willgerodt., *Merk. J. pr.*, (2), **80**, 1917, (1909).

PHYSIOLOGICAL STUDIES IN SALT TOLERANCE OF CROP PLANTS

VIII—INFLUENCE OF IAA SPRAYING ON THE DELETERIOUS EFFECT OF SODIUM SULPHATE ON GROWTH AND MATURITY OF WHEAT.

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Introduction

The problem of saline and alkaline soils has attained the status of a major problem in many countries including India, because large tracts of arable land are rendered uncultivable due to excessive salinity or alkalinity. Further, even under moderately saline or alkaline conditions appreciable reduction in growth and maturity of plants is experienced. Soil salinity is attributed to a high concentration of soluble salts, particularly sulphate and chloride of sodium, and is known to lead gradually to alkaline conditions. Reclamation of such areas is attempted by various agronomical practices as well as by growing tolerant crops or varieties.

In this laboratory, work has been in progress on salt tolerance of crop plants; independently of these studies, investigations have been carried out on the effect of synthetic phytohormones on growth and maturity. Since the results of the latter studies appeared promising an attempt was made to utilise the beneficial effect of presowing soaking of seeds in hormone solution to counter the salt injury to wheat (Sarin, 1959). In the present investigation, however, another method of applying the phytohormones *i. e.*, spraying, is tested to ascertain the utility of the hormones for improving the growth and maturity of crop plants in saline areas. The present paper embodies the investigations on these lines carried out on wheat in pot-cultures during two cropping seasons (*rabi* 1956-57 and 1957-58).

The alluvium of Gangetic basin contains sodium sulphate varying in concentration from 0·026% (on oven-dry basis) in normal soil to 0·269% in saline or alkaline areas (Desai and Sen, 1953). The depressing effect of sodium sulphate on growth and yield of various crop and vegetable plants has been repeatedy established (Lyon, 1941; Magistad et al, 1943; Hayward and Long, 1942 and 1943; Bhardwaj and Rao, 1955 and Sarin, 1959). On the other hand, the stimulating effect of hormones on growth and yield of crop plants has been observed by many workers (Cholodny, 1936; Mc Rostie et

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al, 1938; Amlong and Naundorf, 1939; Hopkins, 1940 and Bhardwaj and Rao, 1955 and 1956). The applicability of phytohormone treatment in nullifying the depression in growth and yield of wheat due to sodium sulphate has been indicated by Sarin (1959).

The use of hormonal sprays against the salt injury has not been reported so far. In the present study, therefore, an attempt has been made to investigate the effect of weekly sprays of IAA (β—indolylacetic acid) on the depression in growth and yield of wheat caused by sodium sulphate in the soil.

METHODS AND MATERIALS

Seeds of wheat C. 591 were sown in the first week of November in earthen pots, each containing 6 lbs. of air-dry soil mixed with compost (1 : 1). Two series were maintained : (i) with sodium sulphate (0·15% on air-dry weight of the soil) added to the pots in solution immediately after sowing. Necessary precautions were taken to collect the percolating soil solution from the pots and to add it back to the same, (ii) normal soil without any added sulphate. Three pots were kept for each treatment. Ten seeds were sown per pot and four weeks after sowing, the seedlings were thinned to three. From then, the plants in one set (having both control and sulphate added pots) were sprayed once a week with 5 ppm solution of IAA. The spraying was continued till maturity.

Four-weekly observations on the growth of the plants were recorded till maturity but in the present paper data on the shoot-dry-weight at maturity and yield of grain is considered. The experiment was conducted during two cropping seasons *i. e.*, *rabi* 1956-57 and 1957-58 and the results were subjected to statistical analysis following analysis of variance method on factorial basis.

RESULTS

The results are summarised in Table 1.

Table 1

Influence of IAA-spraying on the depressing effect of sodium sulphate of shoot-dry-weight and yield of wheat C. 591.

	Normal soil		Na_2SO_4 soil		C. D.		
Season	Cont.	IAA	Cont.	IAA	Sp	Ss	Int
	Shoot-dry-weight in gms.						
1956-57	1·14	1·33	0·74	1·66	0·41	...	...
	Yield of grain in gms.						
	1·63	1·24	0·72	2·03	...	...	0·69

Table 1 (*Contd.*)

1957-58	Shoot-dry-weight in gms.						
	1·03	1·66	0·72	1·67	0·28	...	...
	Yield of grain in gms.						
	1·29	0·85	0 93	1·27	...	...	0·32

Cont : Unsprayed plants.
IAA : IAA sprayed plants.
C.D. : Critical difference at 5% probability.
Sp : 'Spraying' (Main factor)
Ss : 'Salt-supply' (Main factor)
Int : Interaction ('Spraying, x 'Salt-supply')

1956-57 Experiment:

Shoot-dry-weight: For this observation the main factor 'spraying' alone was statistically significant. While the other main-factor 'salt-supply' and their interaction was not significant. The lack of significance for 'salt-supply' was apparently due to relatively better growth in 'salt-supplied and IAA-sprayed' plants.

The IAA spraying improved the growth of plants as evidenced by shoot-dry-weight and there was a reduction in the same due to the salt (though statistically non-significant). Considering the trends of the interaction figures, it is fairly clear that IAA sprayed plants growing in sulphate added soil produced more shoot-dry-weight than unsprayed ones under similar conditions or even unsprayed ones in normal soil. Curiously enough the sprayed plants in normal soil were not better than the control plants.

Yield of grain: Neither of the two main factors were significant while their interaction was so.

The trend of beneficial effect of IAA spraying and of depression by salt supply, observed for shoot-dry-weight, were fairly manifest for yield of grain as well, but a detailed consideration is possible in this case because interaction of the two factors is also significant.

The addition of sodium sulphate to the soil significantly lowered the yield of unsprayed plants. IAA spraying alone did not exhibit any enhancement in the grain-yield and they were as good as control plants. But IAA sprayed plants in 'sulphate-soil' not only yielded better than unsprayed plants under these conditions but also than their own controls (IAA-sprayed plants in normal soil); further, the beneficial effect brought them at par even with the unsprayed plants growing in normal soil.

It was apparent from this year's experiment that inspite of the fact that hormone spraying itself was not instrumental in causing sufficient enhancement in either growth or maturity, the treatment was efficient in neutralising the harmful effect of the salt.

1957-58 Experiment:

Shoot-dry-weight: As in the previous season, only the main factor 'spraying' was statistically significant for this observation while the other main factor 'salt-supply' and their interaction were not so.

In this year's experiment also the general beneficial effect of IAA spraying on shoot-dry-weight and its reduction due to the addition of sodium-sulphate to the soil were fairly evident, though only former was statistically significant. A brief assay of the trends of the interaction figures revealed that even in the normal soil IAA spraying improved the growth of plants. Further, the IAA sprayed plants in sulphate-added soil grew not only better than the unsprayed plants in the 'sulphate-soil' but also better than the control plants in the normal soil. These observations thus confirmed the results of the previous year.

Yield of grain: For this observation, as in the previous year, neither of the two main factors were significant but their interaction was so.

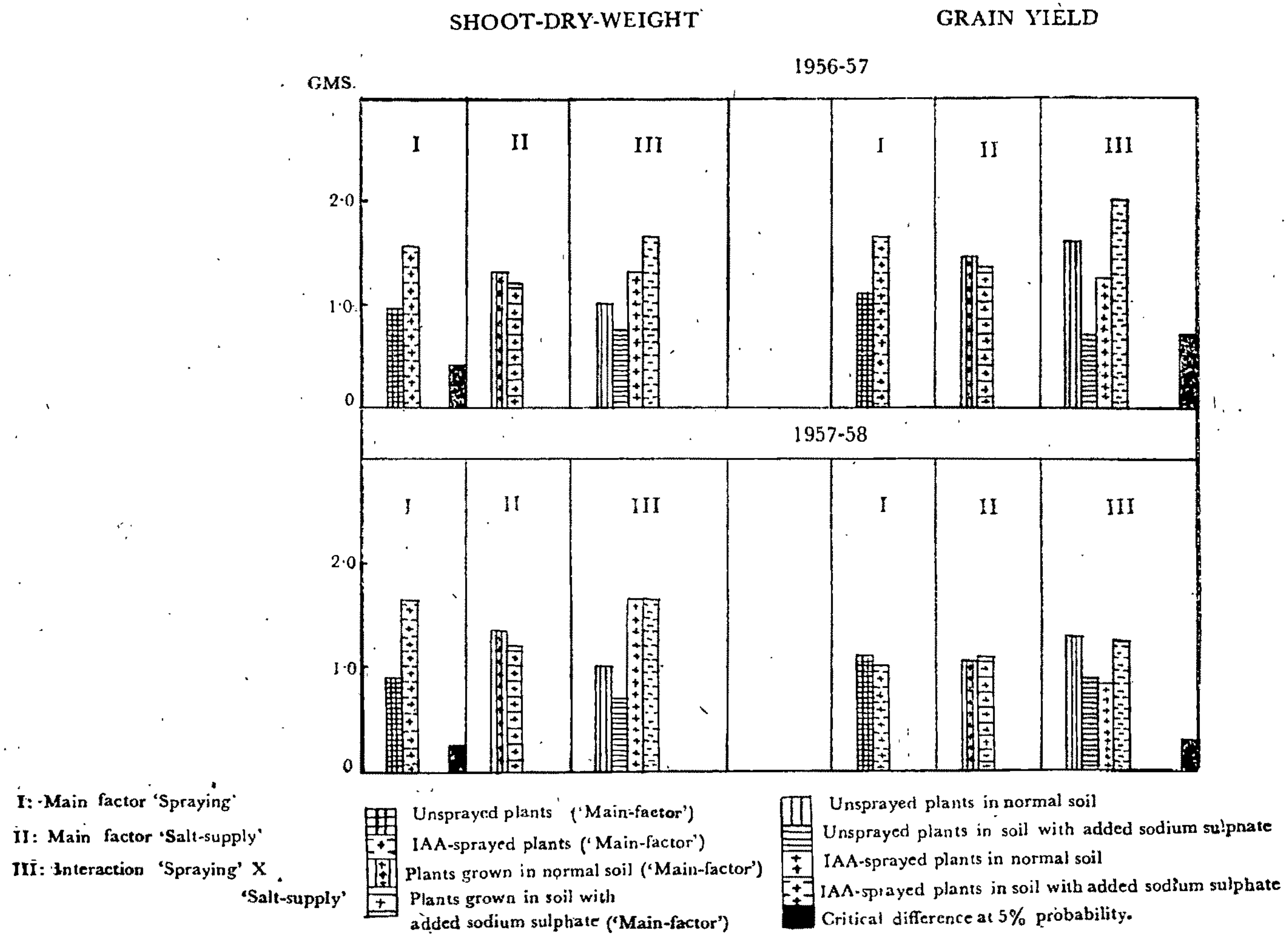
A supply of sodium sulphate lowered the yield of unsprayed plants. IAA spraying on the plants growing in normal soil did not improve their yield and they were as good as the unsprayed plants under these soil conditions. But IAA spraying to plants growing in sulphate added soil significantly enhanced their yield over unsprayed plants. The beneficial effect of phytohormone spray amounted to such an extent that even in the sulphate soil the plants yielded as much grain as the unsprayed plants in the normal soil.

Thus this year's observations confirmed in general the conclusions of the previous experiment regarding the depression in yield of grain due to the salt as well as its subsequent neutralisation by IAA spraying. The influence of IAA-spraying was not apparently beneficial to the growth and maturity of wheat plants grown in normal soil.

DISCUSSION

Although the studies were carried out during two cropping seasons, the results showed apparent variations in the effect of sodium sulphate or of the spraying treatment in different seasons. It is not uncommon particularly with hormone-treatments (Bhardwaj and Rao, 1955 and 1956). However the general trends are clear and become more evident from the following discussion:

As already mentioned in the review of literature sulphate injury to plants resulting in depressed growth was reported by several workers. It was also noted in seedling growth of wheat and gram by the authors (1956). In sand culture too, growth and yield of wheat plants was lowered by a supply of sodium sulphate in the culture solution (Sarin, 1959). In the present study, where sodium sulphate was added to the soil, the adverse effect w fairly evident as shown below :



SHOOT-DRY-WEIGHT
GRAIN YIELD
1956-57
1957-58
GMS.
2·0
1·0
0
I
II
III
I: Main factor 'Spraying'
II: Main factor 'Salt-supply'
III: Interaction 'Spraying' X 'Salt-supply'
Unsprayed plants ('Main-factor')
IAA-sprayed plants ('Main-factor')
Plants grown in normal soil ('Main-factor')
Plants grown in soil with added sodium sulphate ('Main-factor')
Unsprayed plants in normal soil
Unsprayed plants in soil with added sodium sulphate
IAA-sprayed plants in normal soil
IAA-sprayed plants in soil with added sodium sulphate
Critical difference at 5% probability.

Table 2

Percentage of the values for the 'saline soil'
over those for 'normal soil'
(Untreated plants)

Season	Shoot-dry-weight %	Yield of grain %
1956–57	64.9	44.1
1957–58	69.9	72.0
Mean	67.4	58.0

Though there were some variations in the results of the two cropping seasons, yet it was clear that the depressing effect of the salt is more pronounced on the yield as compared to the shoot-dry-weight thus confirming the conclusions of Russel (1950) who remarked, "...cereals will grow and produce much green matter in soil too saline for them to produce any grain".

According to Cholodny(1936), Hopkins (1940) and others, synthetic phytohormones improve growth and maturity of plants, although Barton (1940), Stewart and Hamner (1943) and others contradict the same. Pre-sowing seed-treatments with hormones gave better growth and yield of wheat but the results varied in different years (Bhardwaj and Rao, 1955 and 1956 and Sarin, 1959). In the present study too, considering the effect of IAA spraying of plants in normal soil, it was observed that there was no beneficial influence on growth and yield. However, the main object of the present investigation was to note the effect of IAA on plants growing in saline soil which is clear from the following figures :

Table 3

Percentage of IAA-treated set over untreated set.
(Plants grown in saline soil)

Season	Shoot-dry-weight %	Yield of grain %
1956–57	224.3	281.9
1957–58	231.9	136.5
Mean	228.1	209.2

Although the beneficial effect of IAA spraying in the normal soi lwas absent, in the saline soil it was clear that the hormone spraying improved considerably the growth and yield of wheat plants. It is true that the differences were not always statistically significant which must not really affect the apparent conclusion regarding the beneficial effect of IAA-spraying. The present data confirm the conclusions drawn by Sarin (1959) regarding the beneficial effect of IAA in neutralising the deleterious effect of sodium sulphate on growth and yield when the hormone was used as pre-sowing-seed-treatment as shown below :

Table 4

Comparison of the effect of presowing soaking of seeds and of spraying of plants with IAA on the deleterious influence of sodium sulphate on growth and yield of wheat.
(Percentage of IAA-treated set over untreated set; Plants grown in saline soil).

Treatment	Shoot-dry-weight %	Yield of grain %
*Presowing-soaking	149.8	131.2
Spraying	228.1	209.2

It was clear from the above comparison that presowing soaking, though effective in neutralising the adverse effect of sodium sulphate, does not equal the spraying treatment in its performance naturally because in the former case the supply of the hormone is limited to only first 24 hours while in the latter case it is continued throughout the life span of the plant.

If it is now assumed that the sodium sulphate added to the soil reduced growth and yield of wheat plants, to what extent can spraying of plants with IAA solution help in the 'recovery' of the plants to the original level. Can the plants sprayed with IAA growing in saline soil, grow and mature as well as the untreated plants in the normal soil *i.e.*, can the depressing effect of the salt be overcome completely by the beneficial effect of the hormone? This aspect becomes clear from the following table :

Table 5

Percentage of IAA-treated set in saline soil over untreated set in normal soil.

Season	Shoot-dry-weight %	Yield of grain %
1956-57	145.6	124.5
1957-58	162.1	98.4
Mean	153.8	111.4

---

* Data of Sarin (1959)

Although the conclusion is evident and attractive regarding the utility of hormone spraying of plants in saline soil, the authors do realise that it is as yet perhaps only of academic importance, but they are confident that it opens out a new line of investigation for the improvement of crop growth in saline soils. They have not come across reports of similar studies elsewhere.

Finally, would it be possible to visualise the mechanism of sulphate injury from the present data which, however, relate only to the final performance of the plants. According to Magistad et al (1943) and others the deleterious effect of the salt is merely due to the increase in the osmotic pressure of the soil solution. Other workers (Eaton, 1942 etc.) however, attribute the injury to sulphate toxicity. The fact that sulphate depressed the total growth and yield of wheat and that the growth promoting substance, IAA, neutralised the adverse effect can indicate the injury to be primarily an osmotic effect. IAA is known to increase root-elongation inspite of the objections raised by Aberg (1957). Burstrom (1953) convincingly analyses the various aspects of IAA effect on root elongation. IAA supplied at 5 ppm in sandcultures, increased significantly the total root-growth of potato plants (Baijal and Rao, 1958). Thus, if the growth promoting activity of IAA is accepted, it may then mean that in the present study the depression in growth due to sulphate may be an osmotic effect which was neutralised by IAA. It receives further support from the data on the favourable effect of pre-sowing soaking with IAA in neutralising the retarding effect of sodium sulphate on seedling growth and growth and maturity of wheat (Sarin 1959). Inspite of the above argument in support of the osmotic-injury due to the sulphate, it appears that it may have a 'toxic' effect too, as reduction in growth and yield of wheat plants were neither related to each other nor consistent in the present investigation. All the same, IAA could apparently overcome the toxic effect, if any, of sodium sulphate.

Thus, if a synthetic phytohormone like IAA can neutralise the sulphate injury to growth and maturity of crop plants, it is indeed tempting to attack the salinity problem with more powerful growth promoting substances like gibberillic acid, the reputed wonder chemical.

SUMMARY

Local saline and alkaline soils contain a fairly large amount of sodium sulphate, even upto 0.269% (on oven-dry soil). Depression in crop growth or even complete failure is of common occurence in these areas. The present study was undertaken to evaluate the possibility of neutralising the sulphate injury by IAA-spraying.

Seeds of wheat C. 591 were sown in the first week of November in earthenware pots containing air-dry soil mixed with compost (1:1). Two sets of two series were maintained: (i) with sodium sulphate (0.15% on

air-dry-weight of the soil) added to the soil, (ii) normal soil without any added sulphate. One of the sets were subjected to weekly sprays of 5 ppm solution of IAA, four weeks after sowing, and the spraying was continued till maturity. The experiment was conducted during two years *i. e.*, in *rabi* 1956-57 and 1957-58.

Sodium sulphate retarded the growth and maturity of wheat plants but the yield of grain appeared to suffer more than the shoot-dry-matter production; the average reduction in shoot-dry-weight and yield of grain for the two years amounted to nearly 33% and 42% respectively.

Spraying the wheat plants by IAA soultion increased on an average the shoot-dry-weight by 38% but scarcely affected the yield when the plants were growing in normal soil. In the sodium sulphate added soil, however, IAA spraying increased significantly shoot-dry-weight and grain-yield of plants by 128% and 109% respectively over the unsprayed set; further, IAA-sprayed plants, grown in sulphate soil, showed even better growth and yield than the unsprayed ones in the normal soil, the average increase in the shoot-dry-weight and yield of grain being 53% and 11%. It clearly showed the utility of IAA-treatment to overcome the inhibitive effect of sodium sulphate on growth and maturity wheat plants.

The various probabilities of the mechanism of salt-injury are discussed and the use of synthetic phytohormones in crop husbandry in salt lands is advocated.

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LITERATURE CITED

Amlong, H.U. and Naundorf, G : *Forschungsdienst.* **7** : 46548—2, 1939.

Aberg, B : *Ann. Rev. Plant Physiol.* **8**, 153-180, 1957.

Baijal, B.D. and I.M. Rao : *Proc. Ind. Sci. Congr.* **46**, 1958.

Barton, L.V. (1940) : Some effects of treatment of non-dormant seeds with certain growth substances. *Cantr. Boyce Thompson Inst.*, **11**, 181-205.

Bhardwaj, S.N. and I.M. Rao. (1955) : Studies on the effect of chloride and sulphate of sodium on germination, growth and maturity of gram. *Agra Univ. Jour. Res.* (*Sci.*), **4** (Suppl.), 767-776.

Bhardwaj, S.N. and I.M. Rao (1955) : Studies on the effect of 2, 4-D, NAA and IAA on growth and maturity of wheat. *Jour. Ind. Bot. Soc.*, **34**, 21-28.

Bhardwaj, S.N. and I.M. Rao (1956) : Influence of time of sowing on the effect of 2, 4-D on growth and maturity of wheat. *Physiologia Plantarum*, **9**, 257-264.

Burstom, H. (1953) : Studies on growth and metabolism of roots. IX. Cell elongation and water absorption. *Physiologia Plantarum*, **6**, 262-276.

Cholodny, N. G. (1936) : Hormonization of grains *C R. Acad. Sci. U. S. S. R.*, **3**, 439-442.

Desai, S.V. and A. Sen. (1953) : Studies on the characteristics of saline and alkaline patches in the soil of Pusa. *Ind. Jour. Agr. Sci.*, **23,** 187-202.

Eaton, F.M. (1942) : Toxicity and accumulation of chloride and salphate salts in plants. *Jour. Agr. Res.*, **64,** 357-399.

Hayward, H.E. and E.M. Long. (1942) : Vegetative responses of the Elberta peach on Lovell and Shalil root stocks to high chloride and sulphate solutions. *Amer. Soc. Hort. Sci. Proc.*, **41,** 149-155.

Hayward, H.E. and E.M. Long. (1943) : Some effects of sodium salts on the growth of tomato. *Plant Physiol.*, **18,** 556-569.

Hopkins, J.W. (1940) ; Effect of phytohormone dust seed treatment on growth and yield of barley under greenhouse conditions. *Canad. Jour. Res. C.*, **16,** 510-515.

Lyon, C.B. (1941) : Responses of two varieties of tomato and the F1 generation to sodium sulphate in nutrient medium. *Bot. Gaz.* **103,** 107-122.

Magistad O. C., Ayers, A. D., Wadleigh, C. H. and Gauch, H. G. (1943) : Effect of salt concentration, kind of salt and climate on plant growth in sand cultures. *Plant Physiol.* **18,** 151-166.

McRostie, G.P., Hopkins, J. W. and Grace, N.H. (1938) : Effect of phytohormone dusts on growth and yield of winter wheat varieties. *Canad Jour. Res. C.* **13,** 510-515.

Russel, E. J. (1950) : Soil, Conditions and Plant Growth. Longmans Green and Co.

Sarin, M.N. and I.M. Rao. (1956) : Effect of sodium sulphate on early seedling growth of gram and wheat. *Agra Univ. Jour. Res.* (*Sci.*) **5,** 143-154.

Sarin, M.N. (1959) : Investigations on the effect of sodium sulphate on (a) seedling metabolism and (b) growth and maturity of wheat and gram. Thesis approved for the Ph.D. Degree of Agra University.

Stewart, W.S. and Hamner, C. L. (1942) : Treatment of seeds with synthetic growth regulating substances. *Bot. Gaz.* **104,** 338-347.

ABSORPTION SPECTRA OF SOME OPTICALLY ACTIVE DERIVATIVES OF BRUCINE

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SUMMARY

Absorption maxima of salts of brucine with benzoic, *o*-,*m*-and *p*-hydroxy-, *o*- and *p*-amino benzoic acids have been studied with a view to correlate them with rotatory dispersion data. It has been observed that the value of the absorption maxima in the ultraviolet as calculated from the rotatory dispersion data in the visible region and as obtained by direct observation of one of the absorption bands agrees to within 100 A.U. except in the case of brucine-*o*-amino benzoate in chlorofrom and methanol and in case of brucine-*m*-hydroxy benzoate in ethanol where the differences are larger. An explanation of the observed discrepancies has been given.

INTRODUCTION

The rotatory dispersion of optically active compounds is generally expressible by Drude's equation, namely, $\alpha=\Sigma\frac{K}{\lambda^2-\lambda^2_0}$ where α is specific rotation for wavelength λ, and K and λ_0 are constants. According to Kuhn (1) the 'characteristic' wavelengths (λ_0s) obtained from a study of rotatory dispersion in a region away from absorption are intimately connected with absorption bands which are chiefly responsible for optical rotatory power. A close agreement between the 'characteristic' wavelengths deduced from Drude's rotatory dispersion equation was obtained in case of camphorquinone by Lowry *et al* (2, 3) and in case of *d*-γ-nonylnitrite by Pickard and Hunter (4): Singh *et al* have noticed that sometimes 'characteristic' wavelengths are almost identical with one of the absorption maxima (5, 6) and sometimes it is different (7, 8). The differences are explained on the basis that λ_0s deduced from rotatory dispersion data in the visible region represent only approximately the main contribution to optical activity as according to Condon (9, 10) these terms have average values resulting from combination of several terms of more fundamental significance.

In this paper the authors have studied the ultraviolet absorption maxima of a number of salts of brucine with benzoic and substituted benzoic acids with a view to correlate them with the values of 'characteristic' wavelengths obtained by Manhas and Banerji (11) from rotatory dispersion data in the visible region.

Table 1

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids.

Compound	Brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino benzoate		Brucine-p-amino benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me. OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
4000	...	...	...	...	...	...	...	16.46	8.16	8.49	...
3950	...	...	...	...	...	...	...	...	6.90	...	...
3900	...	...	...	...	...	...	...	21.24	9.03	...	...
3850	...	...	...	...	...	...	...	...	11.68	...	...
3800	...	...	1.064	...	...	...	...	73.84	22.30	10.6	2.65
3750	...	...	...	...	...	...	...	...	49.38	...	...
3700	...	...	27.26	...	...	...	...	242.9	109.4	12.76	10.62

Table 1 (*Contd.*)

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids

Compound	Brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino benzoate		Brucine-p-amino benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me.OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
3650	...	...	...	...	...	...	...	...	110.4	...	...
3600	...	...	12.72	3.99	...	...	...	276.1	112.6	22.30	18.58
3550	...	...	17.02	...	...	...	...	...	...	...	...
3500	6.19	...	21.2	1.33	...	...	...	347.80	90.27	58.41	25.22
3450	8.25	...	31.9	2.66	...	...	...	...	79.65	86.02	26.55
3400	10.32	...	62.7	13.3	...	5.32	...	273.5	73.31	71.15	27.87
3350	13.41	...	70.1	...	...	...	2.66	...	55.75	62.12	42.48

Table 1 (*Contd.*)

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids.

Compound	Brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino benzoate		Brucine-p-amino benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me. OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
3300	34.05	31.9	103.2	39.9	...	37.24	29.76	250.6	43.54	33.98	106.2
3250	165.1	68.11	67.03	196.8	111.7	...	144.7	...	34.51	42.6	233.6
3225	...	...	...	...	399.5	...	...	...	...	...	...
3200	299.3	44.89	111.7	492.1	313.89	303.2	274	253.3	48.85	35.05	228.3
3150	319.7	49.02	71.40	417.6	220.8	422.9	401.7	...	54.69	32.92	140.7
3125	...	...	...	...	183.7	...	...	...	...	...	...
3100	319.9	37.41	57.45	409.6	194.5	286.8	297.6	152.7	45.66	30.79	33.18

Table 1 (*Contd.*)

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids.

Compound	Brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino benzoate		Brucine-p-amino benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me.OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
3075	...	...	...	...	255.4	...	...	...	...	...	...
3050	342.6	74.82	61.71	226.1	194.5	465.8	130.3	...	48.85	36.10	43.80
3000	284.8	55.21	45.75	154.3	142.3	289.9	266.0	34.01	37.17	35.04	21.24
2950	305.5	29.92	31.90	146.3	202.2	252.7	220.8	...	37.72	23.36	99.56
2925	...	...	...	...	111.7	...	...	...	...	...	...
2900	350.9	31.99	29.10	119.2	156.9	303.2	274.0	23.99	37.68	14.86	73.01
2850	342.6	36.64	31.19	210.1	93.1	406.9	228.8	...	24.95	13.80	65.03

Table 1 (*Contd.*)

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids.

Compound	brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino benzoate		Brucine-p-amino benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me.OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Exs Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
2800	336.4	23.70	32.98	194.1	70.54	513.4	255.4	15.93	19.11	8.49	42.48
2775	...	...	...	156.9	90.44	...	...	...	...	...	...
2750	293.1	19.60	32.98	183.5	78.47	236.7	154.3	...	22.83	11.15	47.79
2725	...	...	...	226.1	71.82	...	...	...	...	...	...
2700	305.5	17.54	23.40	172.9	61.18	231.4	250.0	10.62	24.95	11.68	34.46
2650	231.2	17.02	17.02	106.6	35.91	196.8	141.0	...	26.55	10.6	69.03
2625	...	...	...	199.5	27.93	...	...	...	...	...	...

Table 1 (*Contd.*)

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids.

Compound	Brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino benzoate		Brucine-p-amino benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me.OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
2600	140.6	15.99	15.96	79.8	23.94	194.2	202.2	9.29	21.24	12.74	122.1
2575	...	...	...	133.0	...	...	...	...	...	...	...
2550	137.7	40.76	10.70	159.6	15.96	151.7	130.3	...	15.93	6.90	184.8
2525	...	...	...	106.4	...	...	...	...	...	...	...
2500	150.9	17.02	10.64	57.69	10.64	127.7	93.21	26.5	6.37	...	120.8
2475	...	...	...	69.16	...	...	...	...	...	...	...
2450	260.1	18.57	...	47.88	15.96	130.3	135.7	...	3.71	2.12	94.25

Table 1 (*Contd.*)

Ultraviolet absorption of some salts of brucine with benzoic and substituted benzoic acids.

Compound	Brucine benzoate		Brucine-o-hydroxy benzoate	Brucine-m-hydroxy benzoate		Brucine-p-hydroxy benzoate		Brucine-o-amino-Benzoate		Brucine-p-amino Benzoate	
Conc. in gm. moles per litre	0.0048	0.0193	0.0092	0.0037	0.0037	0.00376	0.00376	0.0037	0.0094	0.0094	0.00376
Solvent	Me.OH	$CHCl_3$	$CHCl_3$	Et.OH	Me.OH	Et.OH	Me.OH	Me.OH	$CHCl_3$	$CHCl_3$	Me.OH
Wavelength in A. U.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.	Ex. Coeff.
2400	272.4	3.612	9.57	18.62	27.93	103.7	93.21	15.93	3.18	1.06	66.37
2350	121.8	...	...	15 96	...	74.48	...	...	5.24	...	127.4
2300	179.2	3.096	2.17	7.98	5.32	15.96	5.32	13·27	3.71	...	53.1
2250	58.03	...	...	...	...	74.48	...	6.63	...	...	...
2200	...	...	...	5.32	5.32	15.96	5.32	2.65	2.12	...	...
2150	2.064	...	...	...	...	5.32	...	...	...	...	...
2100	...	...	...	...	...	2.66	...	...	...	...	...
2000	2.064	...	1.06	...	...	...	...	...	...	...	...

EXPERIMENTAL

The brucine salts were prepared according to the method given by Manhas and Banerji (11). The absorption spectra measurements were carried out with the help of Uvispeck Spectrophotometer and the results are recorded in Table 1.

DISCUSSION

In Table 2 is given a comparison of the values of absorption maxima in the ultraviolet as derived from rotatory dispersion data in the visible region and that of the nearest absorption maxima observed directly.

Table 2

Comparison of values of absorption maxima as derived from rotatory dispersion data and that observed directly.

Brucine salt of—	Solvent	Calculated from rotatory dispersion data* (λ_0s)	Observed directly (by plotting graph)
1. Benzoic acid	Chloroform	2929	2350, 3040
	Methanol	3178	3050
2. *o*-hydroxy benzoic acid	Chloroform	3025	3050
3. *m*-hydroxy benzoic	Methanol	3159	3075, 3225
acid	Ethanol	2963	2840, 3195
4. *p*-hydroxy benzoic	Methanol	3068	3000, 3150
acid	Ethanol	2985	3050, 3150
5. *o*-amino benzoic	Chloroform	3821	3600
acid	Methanol	2339	2500
6. *p*-amino benzoic	Chloroform	2932	3050
acid	Methanol	2796	2750

From Table 2 it is evident that in case of brucine salt of *o*-hydroxy benzoic acid the agreement is very close, that is, within ±25 A. U. In other cases the agreement is within 100 A. U. except in the case of brucine-*o*-amino benzoate in chloroform and methanol and in case of brucine-*m*-hydroxy benzoate in ethanol. Here the discrepancies may be due to limitations of the rotatory dispersion data from which the 'characteristic' wavelengths have been calculated. The rotatory dispersion measurements in the case of these compounds was confined to visible spectrum (6708 to 4358 A. U.) and it is not wholly admissible to extrapolate the values beyond this region. Moreover, as pointed out in the introduction (9, 10) the Drude terms represent only average values resulting from a combination of several terms of more fundamental significance and at best only an approximate agreement can be expected between the 'characteristic' wavelengths (λ_0s) calculated from Drude's equation and that observed directly.

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* Manhas and Banerji (11).

It is interesting to note that when a comparison is made in different solvents it is found that the shift of corresponding absorption maxima as calculated from rotatory dispersion data is generally greater than that observed experimentally. Further, the greater is the shift the larger appears to be this difference.

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REFERENCES

1. Kuhn, W. 1929, *Z. Ph. C.*, **B.4**, 14
   1930, *Trans. Farad. Soc.*, **26**, 293
   1930, *Ber.*, **63**, 190
2. Lowry, T. M. and Cutter, J. O., 1925, *Jour. Chem. Soc.*, **127**, 607
3. Lowry, T. M. and French, H. S., 1924, *Jour. Chem. Soc.*, **125**, 1921
4. Pickard, R. H. and Hunter, H., 1923, *Jour. Chem. Soc.*, **123**, 434
5. Singh, B. K. and Amma, M. K. P., 1957, *Jour. Sc. and Ind. Res.*, **16B**, 202
6. Singh, B. K. and Amma, M. K. P., 1957, *ibid.*, **16B**, 486
7. Singh, B. K. and Saxena, B. S., 1958, *Jour. Ind. Chem. Soc.*, **35**, 227
8. Singh, B. K. and Verma, S. M., 1958, *Jour. Sc. and Ind. Res.*. **17B**, 184
9. Condon, 1937, *Rev. mod. Phys.*, **9**, 432
10. Condon *et al*, 1937, *J. Chem. Phys.*, **5**, 1753
11. Manhas and Banerji, 1957, *Proc. Nat. Acad. Sci.*, **26A.**, 285

ADAMANTINOMA JAW*

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Adamantinoma is a tumour peculiar to the jaws because of the element of odontogenesis in it, though it has been found to occur in Tibia and Pituitary gland. It is not a rare tumour but the diagnosis is difficult and controversial and has to be made by an expert histopathologist.

MORBID ANATOMY

Adamantinoma is usually a central tumour but cases are on record which are of peripheral origin. In the mandible it appears as a hard mass expanding the jaw. As it gains size it may ulcerate into the mouth and get secondarily infected.

Section of typical specimen shows large and small cystic area filled with a brownish fluid or gelatinous material. Other areas consist of a more solid tissue, soft or firm in consistency and usually whitish in colour. The growth may present as a fleshy or cauliflower projection into the mouth or as a solid mass of tumour without cyst formation. The tumour may weigh as much as 1500 Gm.

HISTOLOGY

A typical specimen shows masses of epithelial cells, peripheral ones being columnar and arranged in pallisade fashion, and the central stellate cells in a reticular fashion corresponding to the reticular cells of a normal enamel organ. Stroma consists of a very loose areolar tissue or is more often cellular. Blood vessels are frequent. Central areas of epithelial clumps often become cystic and all stages of cyst formation may be seen. In other cases the epithelial cell arrangement resembles that of basal-celled-carcinoma of the skin like Rodent ulcer. Frequently, epidermoid features are present *e.g.*, epithelial pearls or prickle cells. Mitoses may be seen in the more malignant type and changes due to infection and hemorrhages may be present.

Campbell[1] observed in two cases and Sirsat[5] in one case, presence of large granular cells, brightly eosinophilic and occurring singly as a syncitium or as sharply demarcated areas of various sizes amongst typical adamantinomatos tissue. Transition between granular stellate cells and between the granular and columnar cells were also seen. These findings give the appearance of a Myoblastoma in the adamantinomatos tissue. This observation may have no more significance than that of coincidental occurrence of two unrelated lesions or they may be also interpreted as a peculiar variant of uncommon type of adamantinoma, hitherto unnoticed.

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* This is an abstract of the thesis, submitted for the M. S. (Surgery) degree of the Agra University.

HISTO-PATHOLOGICAL VARIATIONS OF ADAMANTINOMA

Depending upon the different varieties of histology encountered in the adamantinomas these are :—

1. Epithelioma type—The cells are poorly differentiated and have great infiltrating power. It is usually a solid type of growth.
2. Stellate type—It is made up of stellate cells as seen in the developed Enamel organ.
3. Ameloblastic type—It is made up of follicles in which the peripheral cells reach the cylindrical or ameloblastic shape but not the function. The so called basal—celled carcinoma of the jaws is closely related to this type. It rapidly grows, tends to metastasize and also recurs early and easily.
4. Acanthoma type—It shows epithelial pearls and prickle cells in the reticulum. This morphology is only a step short of carcinoma.
5. Adamantino-carcinoma—In this type carcinomatous area is seen developing into the adamantinoma.
6. Melanotic type—This variety shows epithelial cells and the space between them having pigment which gives the tumour a bluish black discoloration in the centre.
7. Haemangioadmantinoma—It shows the stroma and epithelial tissue surrounding blood filled spaces.
8. Adenomatos type—In this variety the epithelium tends to differentiate towards glandular structure.

PATHOGENESIS

Lewis[2] and Zegarelli[9] discussed the theories of origin of adamantinoma and propounded the following :—

1. Residual epithelial cell rests—These have been excellently described by Malassez[3]. Proliferation of these cells is thought to give rise to adamantinoma.
2. Proliferation of the Enamel organ and anomalies in the process—It is a vague hypothesis.
3. Mucous membrane epithelium of the jaws—The tumour is supposed to originate in the basal layer of the gum epithelium after which it invades bone.

4. Epithelium of the odontogenic cysts—It is unlikely that all the tumuors originate thus though adamantinomatous tissue might be found in the cyst wall.

Thoma[7] showed examples of all the four possibilities. Zegarelli[9] convincingly showed the origin of tumour from the group of cells forming the outer layer of the enamel organ but Schulenberg[4] feels that these cells correspond to the basal or germinative layer cells of the epithelium from which the enamel organ originated and thus it may be postulated that it is a basal celled tumour.

If the origin of adamantinoma from the basal cells is accepted then the pathogenesis of extra-oral adamantinomas also becomes clear.

Thus according to Schulenberg[4] adamantinomas are examples of Basal-celled carcinoma originating from the epithelial cells from the embryonic cell rests or those driven into the periosteum by trauma. Some types of this tumour are not distinguishable from the so-called basal celled carcinoma of the Maxillary antrum and this fact also supports Schulenbergs hypothesis.

CLINICAL FEATURES

The following clinical features in a series of seventeen cases are being described :—

Age incidence—The youngest patient was only 15 months old and considering the duration of disease 10 months in this case it may be reckoned that disease started in the patient only at 5 months of age. Very few cases are recorded at such a young age.

The eldest patient was 36 years and the majority of cases—10 of them—were either below 20 or so.

Sex incidence—Out of the 16 cases, six were females.

Social status—Almost all cases belonged to the middle or lower class.

Religion—Only one out of the sixteen cases was Muslim, the rest being Hindus.

Duration—It ranged from 2½ months to 6 years. This is the period when the patient began having some noticeable trouble for which he sought relief. The actual lesion might have started long ago.

Site—Maxilla was involved in 3 cases and mandible in 14 cases, the site and distribution being the following :—

Mandible—	Right	7 cases
	Left	3 cases
	Symphysis menti	2 cases
	Whole mandible	2 cases
Maxilla—	Right	2 cases
	Left	1 case

The angle of mandible was involved in all cases.

In five cases the molars and premolars were anomalous and misplaced which may be due to the growth involving the alveolus. Canine tooth was involved only in two cases.

Ulceration and secondary infection, pus discharge and pain was found in 9 out of the 17 cases as the cases sought treatment appreciably late.

X-RAY FINDINGS

Radiographic diagnosis of adamantinoma was positive only in six cases.

Unerupted tooth into the cystic cavity was reported in the skiagram of 3 cases only and in one case the roots of teeth were reported to be projecting into the cavity. Histo-pathologically all these cases were Adamantinoma. This points to the fact that skiagram diagnosis is only suggestive and is incomplete without a biopsy for a definite diagnosis of adamantinoma. Cases were misdiagnosed by radiography prior to operation as follows:—

Osteoclastoma	2 cases
Dentigerous cyst	4 cases
Dental cyst	2 cases
Simple cyst	1 case
Inconclusive	1 case
Radio-opacity of Maxillary Sinus	1 case

BIOPSY

It was positive for Adamantinoma in all cases. In case no. 3 the skiagram suggested osteoclastoma, the biopsy from the growth into the mouth by aspiration needle twice proved epidermoid carcinoma grade III. Finally, the biopsy of the material removed on operation was adamantinoma with epidermoid carcinoma like structure. Such a case has also been reported by Willis[8].

In case no. 10, clinically dentigerous cyst of mandible, the skiagram also suggested same diagnosis but the biopsy report was adamantinoma. The second biopsy after a fortnight revealed epidermoid carcinoma grade II. The third biopsy of the resected mandible showed Adamantinoma with changes of anaplastic Carcinoma.

In case no. 11, clinically Adamantinoma mandible, thrice the biopsy report was fibrous epulis, but the biopsy of the material removed on operation proved adamantinoma.

The above cases stress the need and importance of repeated and deep biopsies in doubtful cases.

Biopsy wound healed in all cases as also observed by Srivastava[6] and Schulenberg[4].

Malignant change was seen in 2 cases only *i. e.*, case no. 3 and 10.

Metastasis was observed in case no. 16 in the lymph nodes

Recurrence was observed only in 1 case *i. e.*, no. 10.

TREATMENT

The standard treatment is complete resection of the part with the growth as the tumour is radioresistant.

Three cases gave history of previous operations (the exact nature of operation being unknown) before seeking treatment in this hospital.

Partial resection of Mandible was done in case no. 3 who had involvement of the whole mandible with gross enlargement of chin. The bone in the region of chin was removed for cosmetic reasons after deep ray therapy had reduced the size of the growth.

Hemimandibulectomy was done in five cases Nos. 5, 7, 10, 14 and 15.

In case no. 11, 3/4th of the Mandible was removed after deep ray therapy had reduced the size of the growth.

Curetting was done in 6 cases Nos. 1, 2, 3, 8, 9 and 10 which were all cystic. The biopsy of curetted material revealed Adamantinoma except in case no. 3 and 10 where Epidermoid Carcinoma was detected. Case no. 10, aged 10 yrs. had anaplastic carcinomatos changes also.

Maxilla was removed in case no. 16 along with the supra-hyoid dissection of the lymph nodes.

Four cases nos. 6, 12, 13 and 17 were too advanced for surgery and so were advised palliative radiotherapy.

There was no mortality after operation.

Table of Adamantinoma as observed by different workers is on the following page:

OBSERVATIONS ON ADAMANTINOMA BY DIFFERENT WORKERS

No.	Author	Total cases	Age	Sex	Duration	Site	Malignancy	Recurrence
1.	Robinson 1937	379	Average 30 years (at time of discovery)	Males 142 Females 169	Average 8.5 Yrs.	293 cases Mandi 84% Maxil, 16%	4.5%	119 cases
2.	Geschickter & Copeland 1949	43	10-35 Yrs (70% of cases)	No mention	5-50 Yrs.	Mandi, 36 cases Maxi. 7 cases	1 case with metastases	Majority one or more time
3.	Schulenberg 1949	88	Around 40 Yrs.	78 cases Male 42 Female 36	No mention	67 cases Mand 79% Maxil 121%	All malignant only a question of degree	No mention
4.	Anders Sonession, 1950	39	13-72 Yrs.	Male 13 Female 26	-do-	Mandi 34 Maxil 5	None of Carcinoma 1 of Sarcoma	14 cases.
5.	Sirsat 1952	15	9-60 Yrs.	Males 11 Females 4	Upto 18 Yrs 6 of less than 1 Yrs,	Mandi 14 Maxil 1	No mention	No mention
6.	Srivastava, S. P. & Sikroria, K.C. 1957	17	$1\frac{1}{4}$-36 Yrs.	Males 11 Females 6	$\frac{1}{4}$-6 Yrs.	Mandi. 14 Maxil. 3	2 cases: Two with metastasis in lymph nodes	2 cases with Carcinomatos changes in Adamanti.

Note—Some percentages not made out because of inadequate number of the cases.

Personal Series of Adamantinoma Cases

No.	Name	Age & Sex	Admitted	Duration	Site	Teeth	Ulceration & secondary infection	Skiagram	Biopsy	Treatment	Type	Metastasis & Mortality
1.	S. C.	11 H.M.	25.11.50	3 Mths	Mandi Rt.	Normal	Nil	Dentigerous Cyst	Admanti. with solid strand of cells & cyst formation	Curetting	Cystic	...
2.	C. P.	16 H.M.	15.12.50	7 ,,	Maxilla Rt.	Upper Rt. Canine missing	Nil	-do-	-do-	-no-	-do-	...
3.	G.	20 H.M.	12.3.51	6 Yrs	Mand. Whole	Edentulous mandi.	Nil	Osteoclastoma	On aspiration of growth twice-Epi-Carci. Operated specimen : Epi-Carci. Finally, adamanti. with Epi. Carci likc structure or vice versa	Deep X'ray & Partial removal of mandible & symphysis menti	Solid	...

Personal Series of Adamantinoma Cases—(*Contd.*)

No.	Name	Age & Sex	Admitted	Duration	Site	Teeth	Ulceration & secondary infection	Skiagram	Biopsy	Treatment	Type	Metastasis & Mortality
4.	L. S.	25 H.M.	12.3.51	2½Mths,	Symphysis Menti	Normal	Nil	Cyst in the region of symphysis menti	Admanti : with soild strand of cells & cyst formation	Curetting.	Mono cystic	...
5.	M.	18 H. F.	11.2.52	4 mths,	Mandible Rt.	Normal	Nil	Dental Cyst	-do-	Resection	-do-	...
6.	M. S.	34 M.M.	1.12.53	10 ,,	Maxilla & Palate Rt.	1&2 Rt. upper molars missing	Present	Dentigerous Cyst	Adeno-Adamantoblastoma	Too Advanced	Solid	...
7.	U.	16 H. F.	29.1.54	2 Yrs	Mand. Lt.	Lower left premolar missing	Present	Adamantinoma	-do-	Resection	Solid as well as Cystic	...
8.	R. P.	30 H.M.	29.7.55	1 Yr.	-do-	Extraction of Carious tooth	Present	Simple cyst	Adamantinoma	Curettng.	Mono-cystic	...

Personal Series of Adamantinoma Cases—(*Contd.*)

No.	Name	Age & Sex	Admitted	Duration	Site	Teeth	Ulceration & secondary infection	Skiagram	Biopsy	Treatment	Type	Matastasis & Mortality
9.	B. S. G.	28 H.M.	12.12.55	2 Yrs.	Symphysis menti	Normal	Nil	Osteoclastoma	-do- (Case no. 8)	-do- (Case no. 8)	Polycystic	...
10.	K. G.	9 H.M.	7.4.56	3½ Yrs.	Mandi. Rt.	Normal	Nil	Dentigerous Cyst.	Adamantinoma from cyst wall with carcinomatous changes*	Curetting 1st & then resection after 1 yr.	Monocystic	Recurrence after curetting
11.	K. B. S.	11 H.M.	21.7.56	6 mths	Whole Mandi.	Displaced & loose	Present	Adamantinoma	Fibros epulicethrice. Operated specimen : Adamantinoma	Deep X'rays followed by resection	Solid	...
12.	P. N.	15mth H.M.	26.7.56	10 ,,	Mandi. Rt.	-do-	-do-	Inconclusive	Adamantinoma	Palliative Deep rays	...	...
13.	R.	16 H. F.	11.11.56	11 mths	Mandi. Rt.	Molar-tooth extracted loose teeth	-do-	Adamantinoma	-do-	Too Advanced	...	...

*Resected Specimen—Adamanti with anaplastic Carci (epidermoid)

Personal Series of Adamantinoma Cases—(*Contd.*)

No.	Name	Age & Sex	Admitted	Duration	Site	Teeth	Ulceration & secondary infection	Skiagram	Biopsy	Treatment	Type	Metastasis & Mortality
14.	R. W.	20 H. F.	11.11.56	2 Yrs.	Mand. Rt.	Rt. last lower molar missing teeth loose & displaced	-do-	-do-	Adamanti.	Resection	Solid as well as cystic	...
15.	R. D.	22 H. F.	25.4.57	3 Yrs.	Mandi Rt.	Caries of Rt. last lower molar tooth extraction	Nil	-do-	-do-	Resection	Solid	...
16.	B. S.	36 H.M.	9.7.57	1 Yr.	Maxil. Lt.	Extraction of leftupper canine Adjacent incisor missing	Present	Sinuses Radio-paque	-do-	Resection-block dissection of supra hyoid lymph nodes.	Solid	Metastasis in glands
17.	V. D.	17 H. F.	OPD	1½ Yrs.	Mandi. Lt.	Nil	Present	Adamanti	-do-	Deep rays operation refused	-do-	Nil

(Total 17 cases)

DISCUSSIONS AND CONCLUSIONS

The table given on page 6 gives an idea about adamantinoma as studied by various workers with vide variations in the observations. Nevertheless, adamantinoma is a disease which affects the younger age group, the lower jaw and the middle or lower class of people according to our observations.

Though the study does not conclusively prove any definite theory of origin of adamantinoma yet it is felt that the abnormality in the development of enamel organ has an appreciable role in the pathogenesis of adamantinoma as its relationship to the dentigerous cyst also suggests. Site of 3rd molar also suggests relationship to an aberrant tooth germ at the angle of the jaw. These tumours may be taken to be examples of primary basal-cell carcinoma originating from epithelial cells of the embryonic cell-rests or those driven into the periosteum by trauma.

The presence of large granular cells in adamantinoma as observed by Campbell[1] and Sirsat[5] was not seen in the present series. Abnormality in teeth *e.g.*, sepsis, caries, noneruption, extraction or misplacement may have an appreciable role in the etiology of some cases of adamantinoma. It may excite or initiate the process. It was found that teeth get loose or misplaced in the majority of cases of adamantinoma. Oral and dental hygiene should, therefore, be given due attention both by the patient and the doctor.

Pain appears to be only a secondary symptom in adamantinoma and the majority of the patients seek medical aid only because of an increasing swelling. In neglected cases and those coming late the growth does ulcerate and get infected and even haemorrhages may occur. In no case in the present series were neurological symptoms encountered due to the growth.

Malignant changes were found only in 2 cases in the present study and evidence of metastasis in two cases only in the cervical nodes. Recurrence was noticed only in two cases treated in this hospital. Three cases were unsuccessfully treated previously at other places but the nature of their treatment being unknown no conclusions can be drawn regarding their recurrence.

Radiography is only an adjunct to the diagnosis of the tumour and the final diagnosis must always rest on a suitable biopsy. In the present series radiographic and biopsy diagnosis coincided only in six cases.

Biopsy is the only sure method of diagnosis of adamantinoma and should be done in every case as far as possible. The following precautions should be observed during biopsy :—

1. Biopsy of oral tumours including adamantinoma should be sufficiently deep as a superficial biopsy may lead to an erroneous diagnosis of Basal-cell carcinoma or cylindroma.

2. Biopsy should always be repeated in doubtful cases. The importance of repeated biopsy examination is very well illustrated by cases no. 3, 10 and 11 of the present series.

3. Histopathological differential diagnosis may present difficulty in some cases, especially in the Mucus and Salivary gland tumours as well as mucus secreting and cystic epidermoid carcinomas and so Adamantinoma should always be differentiated from these. A thorough histopathological examination and preferably of more than one section from the tumour will solve this difficulty in most of the doubtful cases.

Adamantinoma should be considered a malignant tumour and dealt by resection of the growth. In the present series this could not be done in all cases due to the patients not agreeing and so in these only curetting was done or Deep X'rays was advised. Some cases were too advanced for resection.

Radiotheraphy has no curative value in adamantinoma. It may be used pre-operatively to reduce the size of the tumour or in cases unsuitable for Surgery as a palliative measure. Its effect on this tumour is of doubtful value.

Recurrence in most cases of adamantinoma is due to incomplete removal rather than due to any malignancy. It is felt that recurrence should be judged after observation for a minimum period of 10 years after operation.

The distinction of solid and cystic types of adamantinoma serves no purpose and there is no conclusive evidence that solid type is more malignant than the cystic. It is only of pathological importance.

A suitable name for adamantinoma is a controverisal matter but it is felt that a descriptive name like adamantiblastoma with the histological picture of basal-celled carcinoma would be quite appropriate.

All the odontogenic cysts are potentially malignant and it is suggested that their lining wall should be subjected to through histopathological examination for adamantinoma.

SUMMARY

This paper is based on a study of 17 cases of adamantinoma treated in the S. N. Hospital, Agra.

Morbid anatomy and histology and the pathogenesis of adamantinoma has been briefly described.

A list of the cases studied is given followed by the observations, discussions and conclusions.

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BIBLIOGRAPHY

1. Campbell, J. A. : *J. Path. & Bact.*, Jan., 1956.
2. Lewis, D. D. : *Surg. Gyn. & Obst.*, **10** : 28, 1910.
3. Malassez, M. L. : Cited by 4.
4. Schulenberg, C. A. R. : *Annals R. C. S.*, May 1951, p. 329.
5. Sirsat, M. V.: *Ind. J. Med. Res.* **XL** : 4, 555, 1952.
6. Srivastava, S. P.: *Ind. J. of Surg.*, **17** : 1, 1955.
7. Thoma, K. H.: Oral Path. 4th edition & Oral Surg. 1952 Edition.
8. Willis, R. A.: Pathology of Tumours, 1948 (Butterworth, Lond.).
9. Zegarelli, E. V.: *Amer J. Path.*, **20** : 23 ,1944.

PHYSIOLOGICAL STUDIES ON SALT TOLERANCE IN CROP PLANTS XII. INFLUENCE OF SODIUM SULPHATE ON EARLY SEEDLING GROWTH OF WHEAT AND GRAM VARIETIES[1].

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Introduction

The problem of soil salinity is shared by the agriculturists throughout the world. Vast stretches of arable land are rendered uncultivable due to excessive soil salinity which is attributed to relatively high amounts of total soluble salts of which sodium sulphate forms a major component. It may vary from 0·026% in normal soil (Desai and Sen, 1953) to 0·212% (on oven-dry weight of the soil) in highly saline soils (Sen, 1953) of Western U. P. Germination and seedling growth of crop plants as well as later maturity are adversely affected.

Detailed physiological studies relating to the adverse effect of sodium salts on seedling growth or even the growth and maturity of crop plants have not been attempted so far in India in a systematic manner, although during the last two decades much work has been carried out outside India on plant growth as influenced by specific sodium salts in different concentrations and it has been repeatedly established that crops differ in their relative tolerance to the salts. Eaton (1941) observed that beets and tomatoes are more tolerant to sulphate than beans. Similarly Magistad et al (1943) found the following order for decreasing crop tolerance to chloride ; sugar beets, table beets, cotton, alfalfa, cow peas, tomatoes, milo maize, carrots, squash, onion and beans.

The differential response to the salts is not limited to merely crops but their varieties and even strains show it markedly. Thus Lyon (1941) while studying the response of the growth of two strains of tomatoes and their F1 generation to addition of sodium sulphate in nutrient solution, noted that Red Currant was affected less than other two. In this Laboratory Bhardwaj (1958) pointed out that the seedling growth as well as growth and maturity of wheat and gram varieties differ in their tolerance to sodium chloride and sodium carbonate.

However, experimental evidence concerning the varietal differences in response of seedling growth to sodium sulphate is lacking, although the crop differences were reported by the author (Sarin and Rao, 1956). Therefore in the present investigation three varieties of wheat and two of gram were studied in their response to the 'toxic' level of sodium sulphate (determined from the earlier studies, (Sarin and Rao, 1956) to asess whether the relative tolerance of the varieties could be determined at the early seedling stage itself. It would then offer a rapid tool for testing the crops and their varieties regarding their suitability to saline areas.

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METHODS AND MATERIALS

Three varieties of wheat (C. 591, N. P. 165 and Cwn 13) and two of gram (N.P. 58 and N.P. 28) were tested to ascertain the varietal differences, if any, in the response of the seedling growth to sodium sulphate.

Seedling growth studies were carried out exactly as in the earlier investigation (Sarin and Rao, 1956). Test tubes of uniform size were fitted with rolls of filter paper folded at the top into a cone to support the seeds. The tubes were filled with test solutions upto one-third level so that it might not come in direct contact with the growing roots ; the solution being supplied to the roots through the capillary action of the filter paper. Two seeds per tube were transferred to the edge of the filter paper and the roots were allowed to grow between the paper rolls and the glass wall of the tube. The tubes were kept at a temperature of about 30°C in a humid dark chamber.

For each variety, two series, one with distilled water supply ('Control') and the other with a supply of 'toxic' concentration (0·8%) of sodium sulphate solution, were maintained with ten replications. Daily observations upto 96 hours after sowing were recorded for root and plumule length. The total root length at each interval was the main root length for gram because it had only the tap root growing till the end of experimental period. But for wheat, because of its fibrous root system, total length was the total of all the adventitious roots including the main root. Therefore, for wheat, besides total root length, the length of the main root and the number of roots were also recorded and the average root lenght was calculated for each seedling.

It may be noted that the seeds began sprouting 24 hours after sowing and thus the observations on roots could be recorded from 48 hours after sowing upto the end of 96 hours. Regarding plumule growth, only one observation at the end of 96 hours was possible for gram and two (after 72 and 96 hours) for wheat.

The results were analysed statistically on the factorial basis as shown below (replications 10)

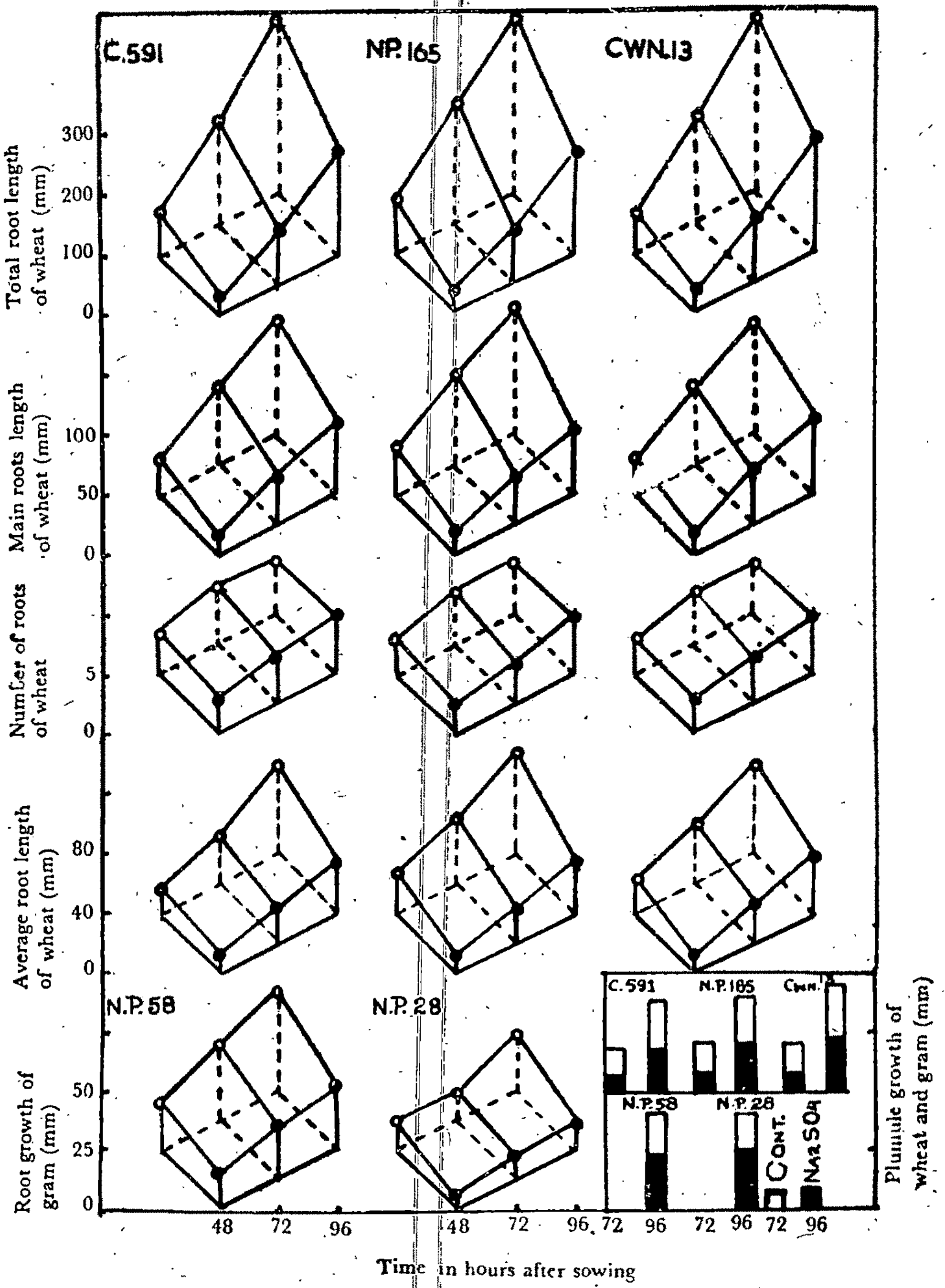

Fig. 1　Effect of Sodium Sulphate on seedling growth of wheat and gram varieties.

Distribution of 'Degrees of Freedom'

	Wheat		Gram	
	Root Growth	Plumule Growth	Root Growth	Plumule Growth
'Varieties'	2	2	1	1
'Salt supply'	1	1	1	1
'Age'	2	1	2	...
Interaction				
(Var. × Salt supply)	2	2	1	1
(Var. × Age)	4	2	2	...
(Salt supply × Age)	2	1	2	...
(Var. × Salt supply × Age)	4	2	2	...
Residual	162	108	108	36
Total	179	119	119	39

RESULTS AND DISCUSSION

The results are tabulated in Tables 1 to 4 which showed the effect of the main factors as well as that of their interactions. The values for respective critical difference at 5% level are also included when the differences between the means were significant.

Observations on total root length, main root length and number of roots, together with the average root length were considered to explore the varietal differences, if any, in the salt effect on root-elongation, rooting capacity and total root length secured at each interval.

Wheat :

Total root length: Irrespective of varieties and salt supply, the total root length of the seedlings increased with the age of the seedlings (Table 1 A III) and regardless of age and varieties, it was significantly retarded by 0.8% sodium sulphate solution (Table 1 A II). The maximum increase in the total root length took place during the fourth day (72 to 96 hours after sowing).

Variety C.591 exhibited maximum increase (Table 1 C) between 72 and 96 hours (112%increase over the value at 48 hours) as contrasted to N. P. 165 (71%) and Cwn 13 (86%).

The adverse effect of sodium sulphate varied with time as well as with the variety (Table 1 B and D). At 48 hours the retardation in the total root length was maximum (56% over the respective controls) but there was a slight recovery with increase in age ; the depression due to the salt compared to control being 46% at 72 hours and 42% at 96 hours. The three varieties, regardless of age, differed in their total root lengths even in the control set (Table 1 B). Variety N. P. 165 was significantly superior to the other two varieties (C. 591 and Cwn 13) which did not differ from each other; but this apparently fast growing variety was much more susceptible to the salt supply than the other to varieties, the depression being 52% in N. P. 165, 46% in C. 591 and 38% in Cwn 13. Thus it is clear that the relatively slow growing variety Cwn. 13 was most resistant to sodium sulphate as regards the total root length, while C. 591, a medium variety was moderately resistant.

A detailed consideration was not possible because the final interaction was not significant.

Main root length: Regardless of the varieties and salt supply the main root length also increased with the age of the seedlings (Table 1 A III) and irrespective of age and variety it was significantly retarded by the supply of sodium sulphate solution (Table 1 A II). The varieties also differed significantly irrespective of 'age' and 'salt supply' (Table 1 A I); main root length of N. P. 165 was definitely superior to C. 591 and Cwn. 13, which did not differ significantly from each other.

Like the total root length, the length of the main root also exhibited its maximum elongation during the third day and slowed down in the fourth day; there were , however, some varietal differences also, though not statistically significant (Table 1 C), N. P. 165 appeared to have slowed down most (the increase in root length from 72 to 96 hours being only 73% of the value at 72 hours) as compared to Cwn. 13 (96%) and C. 591 (116%).

The depressing influence of sodium sulphate varied with age as well as with variety (Table 1 B and D). Like the total root length, the maximum depression was at 48 hours (48% over the respective controls) and there was a slight recovery with increase in age (the depression, as compared to controls, being 41% at 72 hours and 40% at 96 hours) but the differences were not so distinct as for total root length. As in the case of total root length, variety N. P. 165 was characterized by maximum growth of the main root in the control set as compared to other two varieties which were significantly inferior than this (N. P. 165) but did not differ among themselves. But the sulphate injury was highest for N. P. 165 (48% reduction as compared to control);

Cwn. 13 once again proved to be the most tolerant for this observation as well (35% depression) while C. 591 was moderately resistant (42% reduction).

The final interaction, however, was not significant.

Number of roots: The number of roots also increased with the age of the seedlings (Table 1 A III) and was depressed by the salt supply (Table 1 A II). There were varietal differences also, regardless of 'age' and 'salt supply' (Table 1 A I); C. 591 was singificantly superior to the other two and Cwn. 13 was better than N. P. 165 in production of roots.

As in the previous two observations, the root production was maximum during the third day and slowed down in the fourth day. Similarly the adverse effect of the salt (Table 1 D) also was at its peak (17% reduction) on the third day (72 hours after sowing) and showed recovery to control level on the fourth day (96 hours after sowing).

The varietal differences in the response to sodium sulphate (Table 1 B), though not statistically significant, were, however, in conformity with the other two observations; variety N. P. 165 was more susceptible than C. 591 and Cwn. 13 which was least susceptible (3.0% reduction over respective control).

The final interaction was not significant.

Average root length. The average root length also exhibited similar trends (of the main factors) as the other observations *i. e.*, an increase with the age of the seedlings, a clear retardation by salt supply and varietal difference (Table 1 A I, II and III), but here N. P. 165, irrespective of other treatments was the best, next came Cwn. 13 and then C. 591; all the three were significantly different from each other.

Like the other observations, the average root length also showed the maximum increase during the third day. The sulphate injury was, however, maximum at 48 hours (50% reduction over respective controls), then exhibited an apparent recovery at 72 hours (37% reduction) but unlike other observations this recovery could not continue for the fourth day (42% reduction—Table 1 C). This is because the number of roots in the sulphate supplied set equals the control set at 96 hours and that is why inspite of gradual trends of recovery from 72 hours to 96 hours in total root length, there was no recovery observed in the average root length.

The varieties also differed in their response, to salt supply (Table 1 B). As in the other observations, N. P. 165 appeared to be the most susceptible variety for the average root length also and Cwn. 13 was most resistant, while C. 591 was intermediate between the two (the reduction over the respective controls being 48% for N. P. 165, 36% for Cwn. 13 and 40% for C. 591).

Plumule growth : The plumule growth could be measured at 72 hours and 96 hours only, so necessary alterations were made in the statistical calculations.

As in the various observations on the root growth, the plumule growth also increased with the age irrespective of salt supply and varieties (Table 2 AIII) and was significantly depressed by the salt supply regardless of other treatments (Table 2 A II). The varietal differences irrespective of 'age' and 'salt supply' were also quite clear (Table 2 I) and irrespective of 'salt supply' and 'age' N. P. 165 was the best for plumule growth as well but unlike the average root length, variety C. 591 was better than Cwn. 13.

The depression in plumule growth caused by sodium sulphate also varied with age of the seedlings (Table 2 D). At 72 hours there was more retardation (63% over the respective control) followed by a recovery at 96 hours (52% depression only). The varietal difference in their response to sodium sulphate (table 2 B) were not statistically significant but there was a slight indication that N. P. 165 was comparatively more susceptible than either C. 591 or Cwn. 13, the last variety being most tolerant.

The final interaction was not significant.

Gram:

Root growth : In gram only the tap root continued to grow upto 96 hours without further branching so its length at each interval represented total root growth.

The root growth of gram, irrespective of 'varieties' and 'salt supply' increased with the age of the seedlings (Table 3 A III) and regardless of other treatments it was definitely retarded by the sodium sulphate solution (Table 3 A II). Irrespective of the 'age' and 'salt supply' the root growth of variety N. P. 58 was significantly better than N. P. 28 (Table 3 A I).

The root growth of gram N. P. 58 (Table 3 C) showed maximum increase during the third day (70%) as compared fourth day (52%) but N. P. 28 continued to grow with increased vigour even during the fourth day (40% increase during the third day and 50% during the fourth day).

Irrespective of varieties, the sulphate injury also was maximum during the third day (45% depression over respective control) and tended to show a slight recovery on the fourth day (Table 3 B).

The foregoing account did not give a complete picture as the final interaction (Table 3 E) has also become significant.

The root growth in control seedlings of the two varieties did not differ significantly at 48 hours but N. P. 28 tended to show less growth. This trend became more apparent at 72 hours and 96 hours when root growth of N. P. 58 was definitely better than N. P. 28.

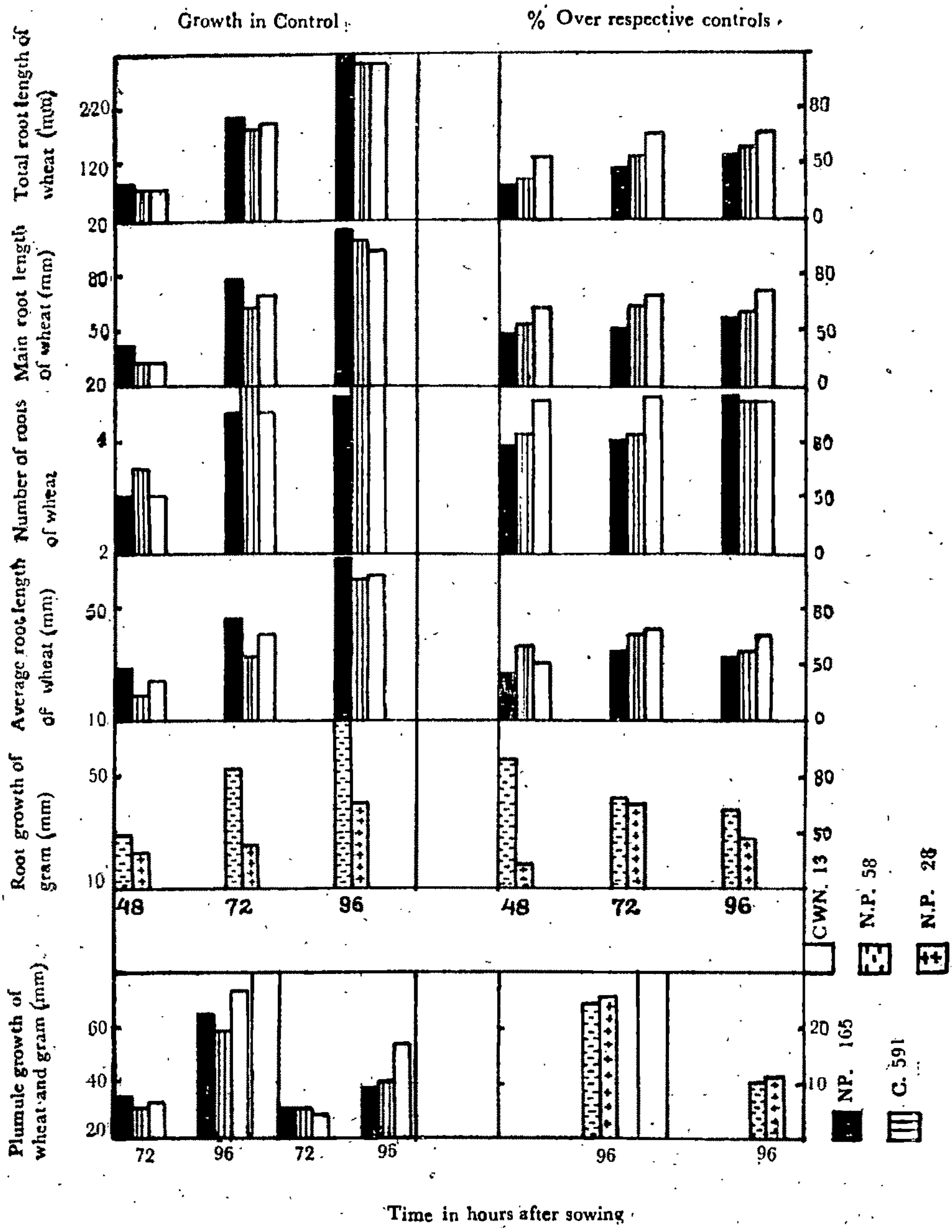

Fig. 2. Influence of Na_2 SO_4 onseedling growth of wheat and gram varieties.

The depressing influence of sodium sulphate on N.P. 58 increased with the age of the seedlings while in N.P. 28 maximum depression was seen at 48 hours (67% reduction over respective control) fo'lowed by a phenomenal recovery (only 33% inhibition at 72 hours) which, however, did not persist so that at 96 hours the inhibition was 53%. In any case the salt injury was more pronounced in N.P. 28 than in N.P. 58 at all ages except 72 hours when the difference was not appreciable.

Thus the relatively slow growing variety N.P. 28 was more susceptible to the salt unlike wheat where the comparatively fast growing variety N.P. 165 was more susceptible.

Plumule growth : The observations on plumule growth were possible only at 96 hours. The two varieties did not differ in their plumule growth nor did they differ in their relative tolerance to the salt because the plumule growth of both the varieties was equally adversely affected by the sodium sulphate.

The differential behaviour of wheat and gram varieties in control as well as in their response to the 'toxic' level (0·8%) of sodium sulphate have been explained above strictly on the basis of statistical analysis and a general consideration based on percentages of treated set over respective controls is worth attempting for understanding varietal differences (Fig. 2).

Comparision of wheat varieties. Root growth : Total root length of control seedlings differed in the three varieties, the variety N.P. 165 fared the best while the differences between Cwn. 13 and C. 591 were, however, not appreciable. Further the varietal differences were comparatively more marked at 48 hours as compared to 72 and 96 hours when the three varieties tended to come close to one another. The main root length also exhibited similar varietal differences, but there appeared to be very little variation between the varieties as regards root production and unlike the other two observations variety C. 591 produced more roots as compared to the other varieties. The average root length, however, exhibited differences; variety N.P. 165 behaved as the best at each interval while Cwn. 13 which was little better than C. 591, comes next.

The three varieties differed in their response to sodium sulphate as well. Total root length of the variety N.P. 165 appeared to be reduced maximally by 0 8% sodium sulphate solution while that of Cwn. 13 suffered least. Almost similar variations were maintained for all the other observations on the root growth of wheat seedlings. It was interesting to note that the relative salt tolerance of the varieties was associated with the growth ; the comparatively fast growing variety (N.P. 165) suffered most due to the salt while the slowest growing one (Cwn. 13) was least affected and the medium growing C. 591 experienced a rather moderate adverse influence.

Plumule growth : The varietal differences in the plumule growth were not clearly seen, however, at 96 hours after sowing there was a tendency for Cwn. 13 to have better plumule growth than the rest two, out of which variety N.P. 165 was slightly better. It was evident therefore that the varieties which may be having quite good growth of the roots may not be equally efficient in plumule growth.

The varietal differences in the response to sodium sulphate were also not evident at the end of 72 hours ; however, at 96 hours Cwn. 13 behaved as the most tolerant variety compared to N.P. 165 and C. 591 which did not differ among themselves.

Comparision of gram varieties—Root growth : The root growth of the two varieties of gram differed markedly but the differences became evident only after 72 hours ; variety N.P. 28 exhibited less growth than N.P. 58 at 72 and 96 hours respectively.

The variety N.P. 58 suffered least at 48 hours unlike N. P. 28 which experienced maximum reduction at this stage. Further, the deleterious influence of the salt increased with the age of the seedlings of the variety N.P. 58 while there was a recovery in N.P. 28 from 48 hours to 72 hours after sowing though this recovery did not persist in the fourth day.

It was evident therefore that the varietal differences in gram due to the sulphate supply were of fundamental nature *i.e.* whether or not there was a recovery with increasing age of the seedlings, unlike those of wheat where the differences relate to the magnitude of reduction in root growth with the sulphate supply, there was no temporary recovery of reduction for any variety.

Plumule growth: Unlike root growth, the gram varieties did not differ in their plumule growth, nor did they vary in their response to sodium sulphate supply. It thus appeared to be a general feature of seedlings (wheat and gram) that the varietal difference were largely restricted to the root growth without being equally manifest in the plumule growth.

As stated earlier (in Introduction), literature relating to the varietal differences in the response of seedling growth or even growth and maturity to salts is scanty, however, crop differences were observed by a few workers (Eaton, 1941, Magistad et al, 1943) and the author has also reported them for seedling growth of wheat and gram (Sarin and Rao, 1956). The varietal differences in response to salts have also been reported by some authors. Thus Lyon (1941), who studied the response of the growth of two strains of tomatoes and their F1 generation to addition of sodium sulphate in the nutrient solution remarked (p. 119) "In comparing the effects of increasing the concentration of sodium sulphate in nutrient solution on the individual strains, it may be noted that Red Currant was affected less than were the other two." Bhardwaj (1958) also noted varietal differences in the response of seedling growth of wheat and gram to sodium chloride and sodium carbonate and stated that variety N.P. 165 of wheat is more tolerant to the two salts than C. 591. This sequence of relative tolerance was also reflected in his (Bhardwaj, 1958) studies on growth and maturity. The present study also confirmed the above findings regarding relative endurance of var. C. 591 and N. P. 165 and thus indicated the possibility of assessing the suitability of the varieties for saline land at a very early stage. The real cause of these varietal variations, however, appeared to be in the inherent characters of the plants.

SUMMARY

Following the technique adopted in earlier studies (Sarin and Rao 1956) seedlings of wheat and gram were grown in test tubes fitted with filter paper rolls. The influence of supplying a 'toxic' concentration of sodium sulphate (0.8%) on early seedling growth of three varieties of wheat and two varieties of gram was studied upto 96 hours after sowing. Daily observations on total root length, main root length and number of roots for wheat and total root growth for gram together with plumule length in each case were recorded and the results were subjected to statistical analysis following the analysis of variance method.

Total root length, main root length, number of roots and average root length, of all the three varieties of wheat (C·591, N. P. 165 and Cwn. 13) were adversely affected by 0·8% sodium sulphate solution and variety N. P. 165 was susceptible to the salt as indicated by all these observations while Cwn. 13 was comparatively tolerant; C. 591 was intermediate. The salt tolerance of wheat appeared to be related to the growth rate of the varieties as the fast growing N. P. 165 suffered most, the slow growing Cwn. 13 suffered least and C. 591 was intermediate in both respects.

Plumule growth of wheat showed trends similar to root growth regarding varietal differences as also their response to salt effect.

Root growth of the two varieties of gram (N.P. 58 and N. P. 28) was not different from each other in the beginning but N. P. 58 fared better than N. P. 28 at the later stage (72 hours and 96 hours after sowing). Salt injury was fairly evident in both the varieties and unlike wheat the comparatively slow growing variety N. P. 28 suffered more as compared to the faster N. P. 58. The varietal differences, though seen at 48 hours tended to disappear at 72 hours while they reappeared at 96 hours after sowing.

The plumule growth of gram, though adversely affected by the salt, did not show marked varietal differences.

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LITERATURE CITED

Bhardwaj, S. N. 1958 : Thesis approved for Ph. D. degree of Agra University.

Desai, S. V. and Sen, A. 1953: *Indian Jour. Agric. Sci.*, **23** (3): 187-202.

Eaton, F. M. 1941: *Plant Physiol.*, **16**: 545-564.

Lyon, C. B. 1941: *Bot. Gaz.* **103** (1) : 107-122.

Magistad, O. C., Ayers, A.D., Wadleigh, C. H. and Gauch, H. G. (1943) : *Plant Physiol.* **18** (2) : 151-166.

Sarin, M. N. and Rao, I. M. 1956 : *Agra Univ. Jour. Res.* (*Sci.*) **5** (1): 143-154.

Sen, A. 1953 : *Indian Jour. Agric. Sci.*, **23** (3) : 203-212.

Table 1

Effect of supplying 0.8% sodium sulphate solution on root growth of wheat varieties.

A. Main factors (I : Variety; II : Salt supply; and III : Seedling age)

I

Observations	Varieties			C. D.
	C. 591	N.P. 165	Cwn. 3	
Total root length (mm)	140.1	150.8	148.9	...
Main root length (mm)	51.6	56.7	53.1	3.4
Number of roots	4.3	3.8	4.1	0.6
Average root length (mm)	29.6	36.0	34.5	2.6

Table 1 (*Contd*)

II

Observations	Salt supply		C. D.
	Control (0%)	Na_2SO_4 (0.8%)	
Total root length (mm)	189.0	104.1	9.2
Main root length (mm)	67.8	39.8	2.8
Number of roots	4.2	3.9	0.5
Average root length (mm)	42.1	26.7	2.1

III

Observations	Seedling age (hrs. after sowing)			C. D.
	48	72	96	
Total root length (mm)	54.6	141.2	244.0	11.2
Main root lengh (mm)	26.6	55.0	79.8	3.4
Number of roots	2.9	4.3	4.9	0.6
Average root length (mm)	17.7	32.7	49.2	2.6

B. Interaction (variety × salt supply)

	Varieties						C. D.
	C. 591		N.P. 165		Cwn. 13		
	Control (0%)	Na_2SO_4 (0.8%)	Control (0%)	Na_2SO_4 (0.8%)	Control (0%)	Na_2SO_4 (0.8%)	
Total root length (mm)	181.6	98.6	202.6	98.9	183.0	114.0	16.0
Main root length (mm)	65.1	38.1	74.4	39.0	64.1	42.2	4.8
Number of roots	4.5	4.0	4.1	3.6	4.1	4.0	...
Average root lengthmm	36.9	22.2	47.4	24.7	41.9	27.1	3.6

Table 1 (*Contd.*)

C. Interaction (Variety X Seedling age)

	Varieties									C.D.
	C. 591			N.P. 165			Cwn. 13			
	48	72	96	48	72	96	48	72	96	
Total root length (mm)	50.0	132.1	238.1	59.2	146.0	247.1	54.6	145.4	246.5	...
Main root length (mm)	24.1	51.4	79.3	30.3	58.8	81.0	25.5	54.8	79.2	...
Number of roots	3.2	4.6	5.1	2.6	4.0	4.8	3.0	4.3	5.0	...
Average root length (mm)	13.4	27.9	46.9	20.6	35.6	51.8	18.6	34.4	50.5	...

D. Interaction (Salt supply × Seedling age)

	Salt supply						C.D.
	Control (0%)			Na_2SO_4 (0.8%)			
	48	72	96	48	72	96	
Total root length (mm)	75.8	182.8	308.6	53.5	99.6	179.4	16.0
Main root length (mm)	34.8	69.1	99.7	18.4	40.9	60.0	4.8
Number of roots	3.1	4.7	4.9	2.7	3.9	5.0	0.9
Average root length (mm)	23.6	40.0	62.6	11.8	25.3	36.9	3.6

48,72 and 96 : Time in hours after sowing.

Table 1 (*Contd.*)

E. Interaction (Variety × Salt supply × Seedling age)

Seedling age (hrs. afer sowing)	Varieties						C.D.
	C. 591		N.P. 165		Cwn. 13		
	Control	$Na_2 SO_4$	Control	$Na_2 SO_4$	Control	$Na_2 SO_4$	
Total root length (mm) :—							
48	70.2	30.1	86.4	32.1	70.9	38.3	...
72	171.9	92.4	199.2	92.9	177.3	113.6	...
96	302.7	173.5	322.4	171.9	300.8	192.9	...
Main root length (mm) :—							
48	31.7	16.5	41.3	19.3	31.5	19.6	...
72	63.8	39.0	77.5	40.2	66.0	43.6	...
96	99.9	58.8	104.4	57.6	94.8	63.6	...
Number of roots :—							
48	3.5	2.9	3.0	2.3	3.0	3.0	...
72	5.1	4.2	4.5	3.6	4.5	4.1	
96	5.1	5.1	4.8	4.9	5.0	5.0	...
Average root length (mm) :—							
48	17.5	10.3	28.7	12.5	24.5	12.7	...
72	33.7	22.1	45.6	25.7	40.3	28.1	...
96	59.5	34.3	67.8	35.8	60.5	40.5	...

Control : Distilled water supply.
$Na_2 SO_4$: 0.8% sodium suplphate solution.
C. D : Critical difference at 5% probability.

Table 2

Effect of supplying 0.8% sodium sulphate on plumule growth of wheat varieties.

A. Main factors (I : Variety; II : Salt supply and III Seedling age)

	Variety			
I	C. 591	N.P. 165	Cwn. 13	C. D.
	31.8	35.0	28.4	3.6

	Salt supply		
II	Control (0%)	Na_2SO_4 (0.8%)	C. D
	48.4	21.7	3.0

	Seedling age (hours after sowing)		
III	72 hours	96 hours	C. D.
	21.7	48.4	3.0

B. Interaction (Variety × Salt supply)

Salt supply	Varieties			C. D.
	C. 591	N.P. 165	Cwn. 13	
Control (0%)	43.8	49.0	52.5	...
Na_2SO_4 (0.8%)	19.8	21.0	24.3	...

C. Interaction (Variety × Seedling age)

Seedling age (hrs. after sowing)	Varieties			C. D.
	C. 591	N.P. 165	Cwn. 13	
72	19.8	22.8	22.5	...
96	43.7	47.3	54.3	...

D. Interaction (Salt supply × Seedling age)

Seedling age (hrs. after sowing)	Salt supply		C. D.
	Control (0%)	Na_2SO_4 (0.8%)	
72	31.4	11.7	...
96	65.1	31.7	...

E. Interaction (Variety × Salt supply × Seedling age)

Seedling age (hrs. after sowing)	Varieties						C. D.
	C. 591		N.P. 165		Cwn. 13		
	Control	Na_2SO_4	Control	Na_2SO_4	Control	Na_2SO_4	
72	29.0	10.7	33.4	12·3	32.9	12.1	...
96	58.6	28.9	64.7	29.9	72.1	36.5	...

Table 3

Effect of supplying 0.8% sodium sulphate solution on root growth of gram varieties.

A. Main Factors (I : Variety; II : Salt supply and III : Seedling age)

	Varieties		
I	N.P. 58	N.P. 28	C. D.
	42.4	20.6	3.6

	Salt supply		
II	Control (0%)	Na_2SO_4 (0.8%)	C. D.
	38.8	24.2	3.6

	Seedlinig age (hrs. after sowing)			
III	48	72	96	C. D.
	20.1	35.6	38.6	4.4

B. Interaction (Variety × Salt supply)

Salt supply	Varieties		C. D.
	N. P. 58	N. P. 28	
Control (0%)	50.1	27.6	...
Na_2SO_4 (0.8%)	34.8	13.6	...

C. Interaction (Variety × Seedling age)

Seedling age (hrs. after sowing)	Varieties		C. D.
	N. P. 58	N. P. 28	
48	25.8	14.4	...
72	44.1	20.3	6.2
96	57.4	27.5	...

D. Interaction (Salt supply × Seedling age)

Seedling age (hrs. after sowing)	Salt supply		C. D.
	Control (0%)	Na_2SO_4 (0.8%)	
48	24.5	15.7	...
72	45.6	25.5	6.2
96	46.4	31.3	...

E. Interaction (Variety × Salt supply × Seedling age)

Seedling age (hrs. after sowing)	Varieties				C. D.
	N. P. 58		N. P. 28		
	Control (0%)	Na_2SO_4 (0.8%)	Control (0%)	Na_2SO_4 (0.8%)	
48	27.5	24.2	21.6	7.2	...
72	52.1	36.2	22.0	14.9	8.8
96	70.9	44.0	39.2	18.7	...

Table 4

Effect of supplying 0.8% sodium sulphate solution on plumule growth in gram varieties.

Salt supply	Varieties		Mean for	C. D. for
	N. P. 58	N. P. 28	'salt supply'	'salt supply'
Control	24.4	24.9	24.6	2.4
Na_2SO_4 (0.8%)	12.8	13.4	13.1	
Mean for 'Varieties'	18.6	19.1		
C. D. for 'Varieties'	...			
C. D. for Interaction	...			

Control : Distilled water supply.
C. D. Critical difference at 5% probability.

THE ALIMENTARY CANAL OF THE LARVA OF THE MANGO LEAF-CUTTING WEEVIL, *DEPORAUS MARGINATUS* PASCOE (COLEOPTERA-CURCULIONIDAE)

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INTRODUCTION

The mango leaf-cutting weevil, *Deporaus marginatus* Pasc. is a serious pest of young mango plants in India and Ceylon. The adults, both male and female, cause damage by feeding upon the lower epidermis and other tissues of the young, tender mango leaves and the gravid females cut the leaves after laying eggs. The larvae mine and feed inside the leaves.

The author has studied the morphology and biology of the adult but any detailed work on the internal anatomy of the larva is lacking. Thus the purpose of this study is to study the anatomical and cellular structures of the alimentary canal of the mature larva.

MATERIAL AND METHOD

Large numbers of live adult specimens of *Deporaus marginatus* were collected from the Botanical Garden of the Agricultural College, Kanpur. The immature stages were obtained by allowing the eggs to hatch and by rearing the emerged grubs in the laboratory in fine wire-gauze cages and glass jars provided with tender mango twigs, inserted in a glass tube containing water to check withering. The mature larvae were dissected in 0.5% saline solution with a pair of fine pointed needle under a binocular micro-scope. For histology of the digestive and excretory organs, the alimentary canal along with the malpighian tubules of the larva was fixed in Bouin's, Carnoy's and Carl's fluids. The best results were obtained by alcoholic Bouin's fluid. The material was kept in this fluid at 70°C for six to ten minutes, then transferred to 70% alcohol and kept overnight. After dehydration and clearing in cedar-wood oil, it was kept in xylol for about five minutes and then embedded in paraffin wax. Section 6-8 μ thick, were cut and stained in Delafield's iron haematoxylin and eosine or orange G.

ANATOMY OF THE ALIMENTARY CANAL

The alimentary canal of the mature larva is composed of three primary divisions, the foregut, midgut and hindgut. The alimentary canal is about one and a half times the length of the body, being looped only in the posterior region of the midgut.

The foregut is small and extends only as far as the anterior half of the mesothorax. The pharynx is small and is followed by a short narrow oesophagus which dilates behind to form a pear-shaped crop which is devoid of any armature.

The midgut extends from the posterior half of the mesothorax to the end of the seventh abdominal segment. It is separated anteriorly from the crop by a constriction. It dilates in the middle to form a sac-like structure and then narrows gradually towards the posterior region and joins the ileum. The anterior half of the midgut is devoid of any intestinal caeca but the posterior half contains about sixteen intestinal caecae. Each caecum is a small finger-like tubercle ending blindly.

The ileum begins from the end of the seventh abdominal segment and extends to the posterior margin of the eighth. It is nearly uniform in diameter. The colon is slightly longer than the ileum and nearly equal to it in diameter. It dilates posteriorly and passes directly into the rectum. The latter is a short, narrow, muscular tube opening outside by the anal aperture, which lies ventrally on the tenth abdominal segment.

Three pairs of malpighian tubes originate round the pyloric valve, between the midgut and hindgut. Each pair is symmetrically situated on either side of the alimentary canal.

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL

Foregut : The pharynx is small and the innermost layer or intima is thick, broad and thrown into a number of folds. The oesophagus (Fig. 2) is about half the pharynx in diameter. Its wall is essentially composed of an intima which is thin and is separated at some parts from the epithelium. It is roughly thrown into six longitudinal folds of unequal heights. Its inner surface is distinctly irregular and wavy. Outside the intima, there is a thin epithelial layer. The nuclei of these cells are moderate in size and oval in shape. The cytoplasm is homogeneous and non-granular. Cell divisions are not distinct, even under very high power of magnification. The basement membrane is not distinct throughout.

The muscularis is prominent and is composed of an inner longitudinal muscle layer and an outer circular muscle layer. The longitudinal muscles are in the form of broad and stout strands, disposed in two groups one in the dorsal and the other in the ventral regions of the oesophagus, just outside the epithelium.

The crop (Fig. 3) is pearshaped with a narrow anterior and a wide posterior region. In the posterior region, the epithelium and its lining intima are thrown into four major longitudinal folds which have nearly flat inner surfaces, alternating with four minor longitudinal ones. The intima of the epithelium cells are small and are closely set one beside the other. The cytoplasm is finely granulated and there are no distinct cell walls separating the nuclei.

The muscularis of the crop has the same structure throughout its length. It is composed of longitudinal muscles which are found as separate fibres outside the epithelium round the crop. Oblique muscles are present at different levels on the epithelium as well as on the intima of the major folds between the longitudinal muscles. The circular muscles form the outermost layer. It is rather thin and encircles the crop completely.

The oesophageal valve (Fig. 4) is a funnel shaped structure projecting into the cavity of the anterior most part of the midgut. It has an inner and an outer fold or lamellae which are produced by the invagination of the foregut epithelium. The intima and epithelium of the inner lamella are thrown into folds. The epithelium is similar in structure to that of crop. Cell divisions are not distinct.

The intima of the outer lamella is thin. The epithelium of the outer lamella is composed of elongate columner cells which are small and separated by distinct cell walls.

The muscularis consists of well developed longitudinal muscle strands which are on the epithelial lining of the folds. The circular muscles are present round the oesophageal valve betweenthe folds. It is comparatively thin and in one layer only. From the histological nature of the oesophageal valve, it is clear that the wall is too rigid to act as a valve and so its function is most likely to conduct the food from the crop to the stomach lumen. The author agrees with Pradhan (1936) that the term oesophageal valve is a misnomer. In the larva the secretion of the midgut passes into the foregut without any action being exercised by the valve. It would, therefore, be proper that the oesophageal valve may be termed the "*oesophageal fold*".

Midgut : The midgut begins at the base of the outer fold of the oesophageal valve and ends just at the base of the malpighian tubes. The midgut is more or less of uniform structure throughout. The digestive cells of the stomach are usually present in variable forms according to their physiological condition. Thus, in some parts the cells may be triangular or conical in form. All these cell-shapes may be present in one and the same part of the stomach. The epithelium of the stomach rests on a basement membrane and the outside of this membrane are found the regenerative cells or nidi. The nidal nuclei may be round or oval, large or small in size, the number varying from one to several in a single nidus. In the majority of the serial sections examined, it was observed that the nidi lie inside the circular muscle layer. The muscularis of the midgut is weakly developed and consists of an inner circular muscle layer and an outer longitudinal muscle layer. The circular muscle layer is not continuous round the midgut but breaks at several parts. The longitudinal layer is thin. The peritrophic membrane was not seen in this species although serial sections were examined.

Hindgut : The hindgut begins just below the bases of the malpighian tubes. From the morphological point of view, the hindgut is divided into an anterior and posterior portions. The anterior part is separated from the midgut by the pyloric valve, and comprises the ileum and colon and posterior part forms the rectum.

The pyloric valve (Figs. 5 & 6) consists of a small internal circular fold formed by the cells of the midgut epithelium. It projects into the cavity of the hindgut just above the invagination of the malpighian tubes. The epithelium of this part of the valve is many layered. The innermost layer bears striated border. The entrance of the hindgut is thus narrowed down by the presence of folds. The muscular layers in this region is very weakly developed.

The ileum is uniform and thrown internally into a number of longitudinal folds. The intima is thin and closely attached to the folding of the epithelium. The epithelial cells are somewhat cubical and are separated by cell walls. The cytoplasm is finely granulated and their nuclei contain little chromatin granules. The muscularis is composed of a thin layer of circular muscles which are continuous round the ileum. The longitudinal muscles are completely absent in this region.

At the junction of the ileum and colon, the six malpighian tubes become closely attached to the wall of the colon, and are enclosed by a thin peritoneal sheath known as fascia (Fig. 8). The space or chamber formed between the colon and the fascia and in which the malpighian tubes lie is called fascial chamber.

The colon differs from the ileum morphologically. The wall of the colon is much thicker and the folds of the epithelium are shorter and broader. The intima is chitinous and the epithelial cells are larger and broader than long. Each epithelial cell is provided with a large nucleus. The muscularis is composed of a thin circular muscle layer. The longitudinal muscle layer is absent and the spaces between the epithelial cells are filled with a somewhat loose connective tissue.

Just above the junction between the colon and the rectum, the circular muscles of the colon end. At this region the fascial chamber round the malpighian tubes communicates with the cavity of the gut by very minute pores which lead into minute canaliculi. The intima at this region is very thin and broken which indicates the presence of these pores.

The rectum is of uniform diameter and is thrown internally into a number of folds. The circular muscles are well developed and always occur in more than one layer. There is no longitudinal muscle-layer.

In cross-section, each malpighian tube (Fig. 7) is seen to consist of two or three epithelial cells surrounding the central cavity. The cell-wall of these cells is absent. The large nuclei of the epithelial cells are round or oval. The cytoplasm is granular. The epithelium cells rest upon a basement membrane which forms the external covering of the tube.

At some parts in the region of the reassociation the malpighian tubes touch the outer covering fascia. Internally the tube is lined with epithelial cells which have striated border and the basement membrane disappear, and the only structure left is a very thin partition formed by the fascia, which separates the cavity of the tube from the general body-cavity. These projections of the reassociated part of the malpighian tubes may facilitate the exchange of water between the cavities of the tubes and the general body cavity.

SUMMARY

The alimentary canal of the larval leaf-cutting weevil, *Deporaus marginatus* consists of three anatomically and histologically differentiated areas, *viz.*, the stomodaeum, midgut and the proctodaeum. The anatomy and histology of the three areas have been described. The oesophageal valve projects into the cavity of the midgut and the inner and outer lamellae of the valve are produced by the invagination of the epithelium of the foregut. The histological nature of the valve indicates that the wall is too rigid to act as a valve and hence its function is most likely to conduct the food from the crop to the stomach lumen. The cells of the midgut are variable in form. The peritrophic membrane has not been observed in this species. The six malpighian tubes are closely reassociated with the wall of the colon and lie in the fascial chamber and may facilitate the exchange of water between the cavities of the tubes and the general body cavity.

ACKNOWLEDGEMENT

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REFERENCES

Auten, Mary. 1933: The structure of the Digestive System in *Bolitotherus cornutus. Ohio Journal of Science*, **33** (4) : 280-286.

Bess, Henery A. 1935 : The alimentary canal of *Calosoma sycophanta* Linnaeus. *Ohio Journal of Science*, **35** (1) : 54-64, 2 pls.

Day, M. Fand, D.F. Waterhouse 1953 : Structure of the alimentary canal. In Roeder, Insect Physiology, New York, *John Wiley & Sons*. pp. 273-298.

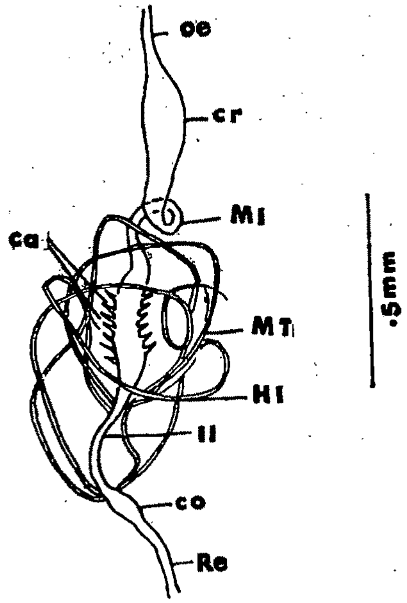
Krall, Jack and Jones, David T. 1943: Morphology of the Digestive tract of Cynaeus angustus Lec., a Tenebnonid. *Iowa State College—Journal of Science*, **17** (2): 221-225, 7 figs.

Lee, A. B. 1937: The Microtomist's Vade-mecurm, 10th Ed., Edited by J. B. Gatenby and T. S. Painter, *P. Blakiston's Son and Co., Inc., Philadelphia.*

Pradhan, S. 1936: The alimentary canal of *Epilachna indica* with a discussion on the activities of midgut epithelium. *Journal Royal Asciatic Society Bengal*, **11** : 127-146.

Snodgrass, R. E. 1935: Principles of Insect Morphology. *McGraw-Hill Book Co., Inc., New York.*

Wigglesworth, V. B. 1953: The Principles of Insect Physiology. *Methuen and Co. Ltd., London.*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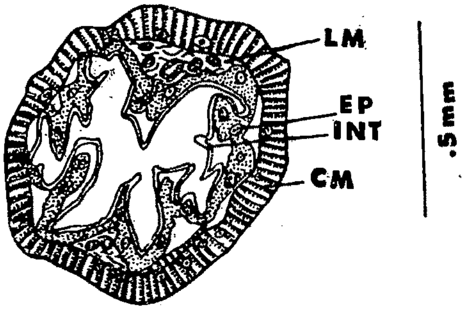
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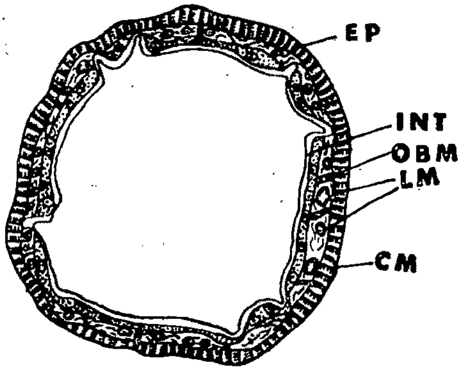
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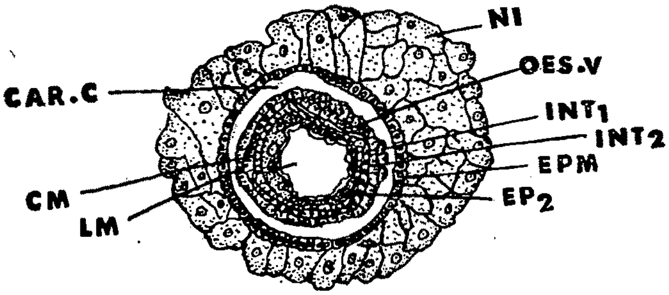
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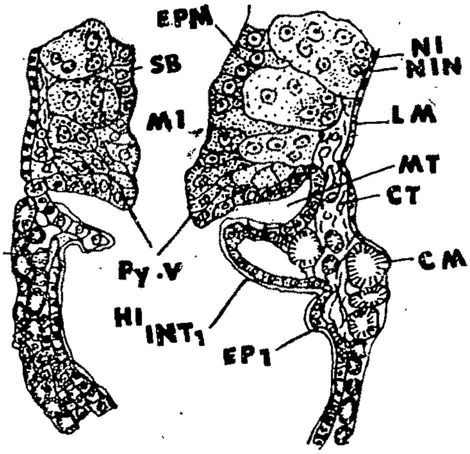
4

EXPLANATION OF THE PLATE

1. Alimentary canal and the associated structure of the larva of *Deporaus marginatus*
2. Transverse section through the oesophagus of the larva.
3. Transverse section through the posterior region of the crop of the larva.
4. Transverse section through the oesophageal valve of the larva.

(Ca— caeca; CAR. C — cardiac cavity; CM— circular muscle; Co— colon; Cr— crop; EP— epithelium; EPM— epithelium membrane; HI— hind-gut; Il— ileum; INT— intima; LM— longitudinal muscle; MI— mid-gut; MT— malpighian tubule; Oe— oesophagus; Oes. V— oesophageal valve; OBM— oblique muscle; Re— rectum)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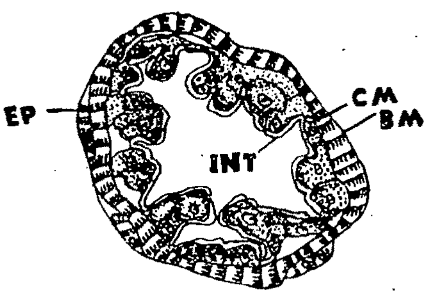
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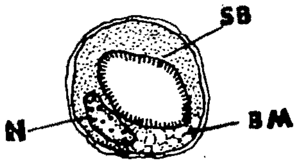
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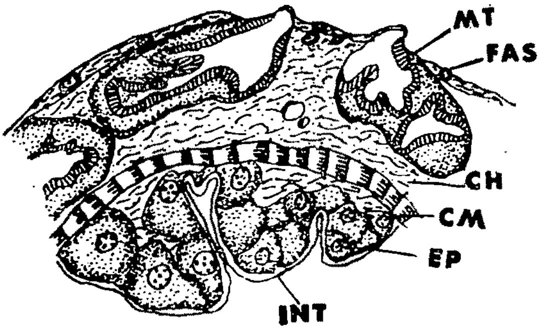
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8

EXPLANATION OF THE PLATE

5. Longitudinal section through the pyloric valve of the larva.
6. Transverse section through the mid-region of the ileum of the larva.
7. Transverse section through the malpighian tubule of the larva.
8. Portion of a transverse section through the colon of the larva under high power.

(BM— basement membrane; CM— circular muscle; CH— fascial chamber; EP— epithelium; EPM— epithelial membrane; FAS— fascia; HI— hindgut; INT— intima; LM— longitudinal muscle; MT— malpighian tubule; MI— midgut; N— Nucleus; NI— nidi; Nin— nidal nucleus; Py. V— pyloric valve; SB— striated border)

REACTIVE METHYLENE COMPOUNDS-A SYSTEMATIC STUDY SUMMARY*

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The reactivity of the hydrogen atoms in methylene compounds under the influence of different electronegative groups, has long been known. Such compounds react with metals like sodium, potassium, copper etc., to give the metallic derivatives which readily condense with compounds having a reactive halogen atom and with different aromatic diazonium salts to yield the corresponding benzeneazo compounds. Due to the presence of carbonyl groups in many of the reactive methylene compounds they as well as their derivatives can be made to yield a variety of open chain and cyclic compounds.

In the present work a more detailed investigation of some reactive methylene compounds, such as, diethyl malonate, acetoacetic esters, benzoylacetones, dibenzoylmethanes, 2,4-dinitrophenylacetic esters, indane-1,3-dione, 5,5-dimethyldihydroresorcin etc., has been undertaken. Among them are a few, such as, 2-chloro-5-methylbenzoylacetone, 3,4-dichlorobenzoylacetone, ω-benzoyl-2,4-dichloroacetophenone, ω-benzoyl-2,5-dichloroacetophenone and ω-benzoyl-3,4-dichloroacetophenone which had not been synthesised before.

These compounds have been found to react in cold with a number of aromatic diazonium salts to give the so-called benzeneazo derivatives. The diazonium salts have been obtained from different anilines, such as, aniline, 4-bromoaniline, 4-chloroaniline, 3-chloroaniline, 2-chloroaniline, 3-nitroaniline, 4-toluidine, 3-toluidine, 4-anisidine, 4-nitroaniline, 2-chloro-4-nitroaniline, 2-nitro-4-chloroaniline, 2,4-dinitroaniline, 2,6-dinitroaniline etc.

It has been observed that the rate of condensation of different benzenediazonium chlorides with a particular reactive methylene compound is different and generally those that have in para position an electronegative substituent couple more readily while that have a methyl or methoxy group less readily.

Different reactive methylene compounds also couple with a particular benzenediazonium chloride at different rates. It has been observed that the rate of coupling is in the order given below :—

Methyl 2,4-dinitrophenylacetate < 2,4-dinitrophenylacetone < diethyl malonate < ethyl acetoacetate < acetylacetone < benzoylacetone < dibenzoylmethane < indane-1,3-dione < dimedone.

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* This is an abstract of the thesis submitted for the Ph. D. degree of the Agra University in 1959-60.

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Some β-diketones, such as, acetylacetone, dibenzoylmethane, dianisoylmethane, ω-benzoyl-4-methoxyacetophenone and ω-benzoyl-4-methylacetophenone have been condensed with substituted phenylhydrazines, such as, 2,4-dinitro-, 2,6-dinitro-, 2,4-dinitro-5-methyl-, 2,4-dinitro-5-chloro-, 2,4,6-trinitro-, 2-nitro-4-chloro-, 2-chloro-4-nitro-, 2-nitro-5-chloro-, 2-bromo-4nitro and 2-nitro-4,5-dichloro-phenylhydrazines and give the corresponding pyrazole derivatives.

The behaviour of benzeneazo derivatives of β-diketones is similar and when, benzeneazo-, 4-chlorobenzeneazo-, 4-methoxybenzeneazo-, 4-bromobenzeneazo-, 3-chlorobenzeneazo-, 2-chlorobenzeneazo-, 4-nitrobenzeneazo-, 3-nitrobenzeneazo-, 4-methylbenzeneazo-, 3-methylbenzeneazo, 2-nitro-4-benzeneazoacetylacetones, benzoylacetones and dibenzoylmethanes and phenylhydrazine are condensed, the corresponding 4-benzeneazo pyrazole derivatives are formed.

Diketones ($R.CO.CH_2.CO.R'$) which are symmetrical ($R=R'$) can yield with phenylhydrazine only one pyrazole but those that are unsymmetrical (R and R′ different) can give two isomers. Only one pyrazole, however, could be isolated in such cases also. The structure has been established by synthesising them from dibromides of benzal substituted acetophenones.

Benzeneazo derivatives of ethyl acetoacetate react with phenylhydrazine yielding the benzeneazo derivatives of pyrazolones. In this way a few derivatives of pyrazolones from benzeneazo derivatives of ethyl acetoacetate, such as, 2-chlorobenzeneazo-, 3-chlorobenzeneazo-, 4-chlorobenzeneazo-, 4-methoxybenzeneazo-, 3-nitrobenzeneazo-, 2-nitrobenzeneazo-, 2-nitro-4-chlorobenzeneazo-, 2,5-dichlorobenzeneazo- acetoacetic esters have been prepared.

4-Benzeneazo derivatives of 1-carbamide-3-methyl-5-pyrazolone have been obtained by coupling aromatic diazonium salts with 1-carbamide-3-methyl-5-pyrazolone in cold. These derivatives lose carbamide group on heating for a short time in alcohol.

4-Benzeneazo derivatives of 3,5-dimethylisoxazole, 3-methyl-5-phenylisoxazole and 3,5-diphenylisoxazole are formed when the benzeneazo derivatives of β-diketones and hydroxylamine are condensed. For this purpose benzeneazo derivatives obtained by the action of diazonium salts of aniline, 4-bromoaniline, 4-chloroaniline, 3-chloroaniline, 2-chloroaniline, 4-toluidine, 3-toluidine, 4-nitroaniline, 3-nitroaniline etc., on acetylacetone, benzoylacetone and dibenzoylmethane have been condensed with hydroxylamine and the corresponding derivatives obtained.

It has been observed that 4-benzeneazo-, 3,5-dimethylisoxazole on heating at about 150° isomerises to an oily product. The 2,4-dinitrophenylhydrazones of the oily product and of 2-phenyl-4-methyl-5-acetyltriazole have been found to be identical. The latter has been obtained from the product of cyclisation of N-methylphenylhydrazone of monoxime of dimethyl triketone and 2,4-dinitrophenylhydrazine.

A few benzeneazo derivatives of ethyl acetoacetate, namely, benzeneazo-, 4-methoxybenzeneazo-, 4-chlorobenzeneazo-, 3-chlorobenzeneazo-, 2-chlorobenzeneazo-, 3-nitrobenzeneazo-, 2-chloro-4-nitrobenzeneazo-, 2-nitro-4-chlorobenzeneazo- and 2,5-dichlorobenzeneazo have been reacted with hydroxylamine and the corresponding 4-benzeneazo-5-isoxazolones obtained.

Benzeneazoacetoacetic esters on treatment with sulphuric acid, hydrochloric acid, aniline and anhydrous aluminium chloride do not yield ketones but get de-esterified. Benzeneazoacetoacetic acid, such as, benzeneazo-, 4-chlorobenzeneazo-, 3-chlorobenzeneazo-, 2-chlorobenzeneazo-, 2-nitrobenzeneazo-, 4-nitrobenzeneazo-, 2-chloro-4-nitrobenzeneazo- and 2,5-dichlorobenzeneazo- have been obtained from the corresponding ethyl (or methyl) benzeneazoacetoacetates and a few of their properties studied.

Metallic derivatives of some reactive methylene compounds, such as, acetylacetone, benzoylacetone, dibenzoylmethane, 2,4-dinitrophenylacetic esters, idane-1,3-dione, dimedone etc., have been condensed with some polynitrohalogenobenzenes namely, 1-bromo-2,4-dinitro-, 1,3-dichloro-4,6-dinitro-, 1,4-dichloro-3,5-dinitro-, 1-chloro-3-methyl-4,6-dinitro-, 1,4-dibromo-3,5-dinitro-, 1-chloro-2,4,6-trinitro-, 1-methyl-4-chloro-3,5-dinitro-, 1,3,5-tribromo-2,4-dinitro-, 1-chloro-3-methyl-2,4,6-trinitro-, 1 ,3-dichloro-2,4,6-trinitro-, 1,2-dichloro-4,6-dinitro and 1-chloro-2-bromo-4,6-dinitrobenzenes and the corresponding derivatives obtained. No condensation, however, takes place in case of metallic derivatives of substituted dibenzoylmethanes.

1-(Substituted phenyl)-3-methyl-5-pyrazolones themselves react readily with polynitrohalogenobenzenes yielding the 4-substituted-5-pyrazolones derivatives. In this way a few derivatives have been obtained.

6-Nitroanthranil has been prepared by a simple method *i. e.*, by heating 2,4-dinitrophenylacetic acid with concentrated sulphuric acid.

Some polynitrophenyl derivatives of β-diketones such as, acetylacetone, substituted benzoylacetones etc. have been hydrolysed with moderately concentrated sulphuric acid, an acetyl group is eliminated in each case and a monoketone obtained. A few substituted phenylacetones and phenylacetophenones, such as, 2,4-dinitro-5-chlorophenyl-, 2,6-dinitro-4-bromophenyl-, 2,6-dinitro-4-methylphenyl-, 2,4-dinitro-3,5-dibromophenyl-, 2,4,6-trinitro-5-chlorophenyl- etc., acetones and acetophenones have in this way been prepared. Similarly, (2′,4′-dinitrophenyl)- and (2′,4′-dinitro-5′-chlorophenyl)- derivatives of 4-chlorobenzoylacetone, 4-bromobenzoylacetone, anisoylacetone, 3,4-dichlorobenzoylacetone and 2-chloro-5-methylbenzoylacetone have been found to give the corresponding ω-(2′,4′-dinitrophenyl)- and ω-(2′,4′-dinitro-5′-chlorophenyl)-substituted acetophenones.

A hydrogen atom of the reactive methylene group gets easily replaced by bromine by treating either the compounds or their metallic derivatives with bromine. Thus, mono bromo derivatives of α-formyl acetophenones, benzoylacetones, dibenzoylmethanes by bromination of their copper or sodium derivatives have been prepared. Better yields of purer products are obtained when copper salts are used. Some phenacyl bromides have been obtained by the bromination of acetophenones. These compounds yield 2,5-diphenylpyrazines when treated with alcoholic ammonia.

The bromine atom in all these compounds has been found to be quite reactive and liberates iodine quantitatively from an acidified aqueous alcoholic solution of potassium iodide.

A STUDY ON THE DEPOSITION OF POLYACRYLONITRILE IN WOOL BY THE PERSULPHATE CATALYST SYSTEM AND ITS EFFECT ON THE FELTING SHRINKAGE OF WOOL

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Introduction

Earlier works have shown that polymerisation of acrylonitrile in wool, leading to products having improved properties *e. g.*, reduced milling shrinkage, can be carried out either by the persulphate[1] or ferrous ion hydrogen peroxide[2] catalyst systems. Whereas with the former catalyst system deposition of the polymer in sufficient amounts so as to give adequate shrink proofing could be done in a short period in the atmosphere of air, with the latter system the reaction vessel had to be purged of air if fairly good deposition of the polymer was required.

It was, therefore, thought that preferential internal polymer deposition might be obtained in presence of air if wool is first impregnated with iron and then treated with acrylonitrile and the persulphate catalyst. The results of this polymerisation treatment are presented in this paper.

Experimental

The treatments were done either on wool flannel (5.8 oz. per sq. yard) or on Lincoln wool.

The sample of flannel was immersed for 2 hours at 25°C in a solution of ferrous ammonium sulphate (0.2%; liquor to wool ratio 10:1) made 0.01 N with sulphuric acid, pressed between filter papers until all surface moisture had been removed, and then dried in air. Polymerisation was carried out at 50°C in glass tube, fitted with a dropping funnel, which could be sealed off by means of stop cocks. The sample together with distilled water, potassium persulphate solution and sufficient N—sulphuric acid to make the final solution 0.01 N was placed in the vessel. Acrylonitrile which had been distilled at 77°—78°C at 750 mm. was admitted and after sealing the vessel the reaction time was taken from this point. When the reaction had proceeded for the required time the sample was washed first in a stream of tap water and then in distilled water until all the loose polymer adhering on the sample was dislodged. The increase in weight of the sample was then calculated from the dry weights before and after the treatment, the former being estimated from regain determinations on control samples.

The extent of felting was determined by measuring the compression resistance of the wool samples, after different periods of milling, with the help of Shirley Institute Thickness Tester.

The results of the polymerisation are given in Table 1.

Table 1

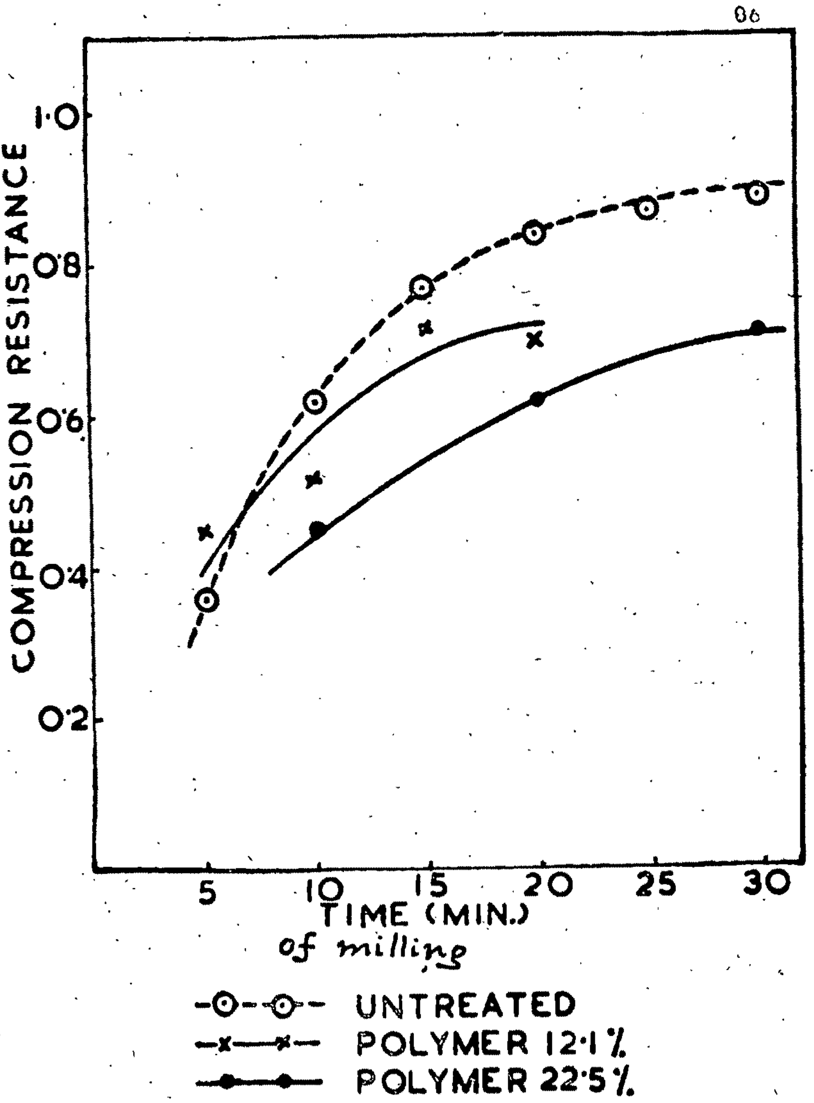
Monomer Coner (%). (v./v.)	Time (hrs).	Persulphate conen. (%). (w./v.)	Liquor: wool Ratio.	Percentage Increase in weight of flannel (average of three readings).
5	1	0.05	50:1	14.9
5	1	0.1	50:1	31.1
5	1	0.2	50:1	36.1
5	1	0.3	50:1	37.1
5	1	0.3	25:1	25.6
3	1	0.3	50:1	22.7
3	½	0.3	50:1	13.0

In order to study the effect of polymer deposition on the milling shrinkage, two samples of Lincoln wool after treatment with ferrous ammonium sulphate were reacted with 3% acrylonitrile at 50° for ½ hour and 1 hour respectively using 0.3% potassium persulphate as catalyst ; they gave weight increases of 12.1% and 22.5% respectively. Their milling shrinkage was compared with that of untreated wool, with the results shown in figure. 1.

SUMMARY AND CONCLUSION

Sufficiently large amounts of polyacrylonitrile so as to be of technical value can be deposited in wool in a short period of one hour in the ordinary atmosphere of air using ferrous ion-persulphate catalyst system. The deposition of polymer reduces the milling shrinkage of wool.

FIG.1



REFERENCES

1. Lohani, Valentine and Whewell, *J. Text. Inst.*, 1958, **49**, T 265.
2. Valentine, *J. Text. Inst.*, 1955, **46**, T 270 ; 1956 **47**, T. 1.

STUDIES ON THE BIONOMICS AND MORPHOLOGY OF CERTAIN INDIAN CURCULIONIDAE (RHYNCHOPHORA-COLEOPTERA)*

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The family curculionidae (order-Coleoptera) constitutes the largest family, in the class Insecta. About 70,000 species, out of the total of about 2,00,000, have been so far described. Some of these are the most serious and notorious insect pests of the world. The author has undertaken a detailed study of the morphology and bionomics of the two species, *viz.*, *Deporaus marginatus* Pasc. and *Cylas formicarius* Fabr. The present work includes the external morphology, the digestive, excretory and nervous systems of the larva and adult, reproductive systems of the adult male and female and the histology of the alimentary canal of the larva of *Deporaus marginatus* Pasc. only.

BIONOMICAL STUDIES

Deporaus marginatus Pasc.

The systematic position and the distribution of the weevil has been discussed. The author has observed the weevils feeding only on mango plants. The nature and extent of damage has been dealt in detail.

Studies on the life history of this pest under different climatic conditions indicate that copulation takes place during the morning hours only and lasts for 5 to 30 minutes. A female may copulate several times with a male who in turn can impregnate several females in its life. Both polyandry and polygamy are common and mating repeated many times. The copulated female starts oviposition one day after the copulation but after subsequent copulations it may take place only after five hours. The eggs are laid on either side of the midrib of the leaf. After completing the egg laying the female moves towards the base of the leaf and cuts away the portion of the leaf containing the eggs by making a transverse incision across the leaf with its sharp mandibles. The cut looks so clear as if made by a pair of scissors. The total number of eggs laid by one female during the entire period of fecundity is on an average 152 and the period of oviposition ranged from 50 to 63 days. It was observed that weather conditions have very little influence on the oviposition. The incubation period ranged from 2 to 3 days and about 72.5% of the eggs laid are hatched. The larva undergoes three moults. The duration of the larval stage varies from 7 to 9 days. The prepupa forms an ovoid earthen cell for pupation. The pupal period varies from 9 to 15 days. The total life cycle is completed in 18 to 27 days.

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* This is an abstract of the thesis submitted for the Ph.D. Degree of the Agra University in the year 1958.

Observations on the seasonal history of the pest indicate that there are five to six generations during the active period from August to November and the activity decreases with the advent of winter. Hibernation takes place in the prepupal stage, and starts from the first week of December when the full grown larvae enter the soil. The population of the pest is maximum in the month of August-September and their number gradually decreases in October-November. The number of leaves cut varies with the number of weevils present and is maximum in August-September. The weevils are negatively phototropic.

Cylas formicarius Fabr.

The systematic position of the insect has been discussed. The species of the genus *Cylas* found at Kanpur (Uttar Pradesh, India) has been identified to be *formicarius*.

Previous records of the distribution of this species indicate that besides the sweet potato growing tracts of India it occurs in Ceylon, Java, Queensland, Phillipines, Cochin-China, Medagascar, West Indies, Hawaii Islands, Florida, Texas and Lousiana.

It is a specific pest of sweet potato crop although reported to feed on the plants of convolvulaceae family. The author observed the weevils feeding on sweet potato alone.

Studies on the life history of the pest under different weather conditions indicate that copulation takes place 4 to 6 days after emergence of the female and lasts for 15 to 20 minutes. The eggs are laid on the vines or tubers after boring a hole with the help of her mandibles and snout and is nearly as wide as the diameter of the head. The oviposition period varies from 29 to 42 days. The incubation period occupies 4 to 6 days in March to October and 7 to 9 days during November to February. There are five larval instars. The duration of the larval stage varies from 19 to 22 days in March to September when the atmospheric temperature is high but during cooler months it ranged from 27 to 30 days. The pupal period varies from 5 to 9 days. The longevity of the male is more than the female.

Observations on the seasonal history of the pest indicate that the periods of greatest activity and most rapid increase in their numbers correspond with the sprouting of new shoots after rainfall. The highest population has been observed from the later half of July to September when the temperature ranges from 82°F to 99·5°F and humidity 77% to 95%. The pest does not pass through a definite period of hibernation and nine generations were observed during a year. The pest is negatively phototropic.

External Morphology of the larva

In the head various areas and sutures have been determined and an attempt has been made to clear the controversy regarding the inverted Y-shaped line which has hitherto been designated as the 'epicranial suture'. Du Porte (1946 and 1957) asserted that this line has no structural significance at all, as it is merely a line of weakness in the head wall along which the cuticle splits at the time of ecdysis. The presence of such a line along which cuticle splits has been noted in almost all immature insects. He termed this line as 'ecdysial suture or line'. Snodgrass (1947) not agreeing with Du Porte's terminology termed it as the 'ecdysial cleavage line'. This term appears to be more appropriate, because the word cleavage explains its function clearly. Moreover it is in no sense a suture because along such a line the exocuticle is wanting and the endocuticle extends upto the epicuticle. It is post embryonic in origin. Thus the central triangular area of the head bounded by the epicranial suture dorsally is regarded the clypeus while the area dorsal to the epistomal suture has been shown to be frons. The rostrum as an outgrowth in the head of the larva is wanting in the present species. The structure and morphology of the mouthparts and other head sclerites has been described in detail.

The structure of various thoracic and abdominal segments has been described.

External Morpholo gy of the adult

A complete description of the head sclerites and the mouthparts has been given. The head capsules of the two species are of prognathous type. The component parts are fused together due to high sclerotisation and the various sutures demarcating them are not well defined. The absence of 'ecdysial cleavage line' and the suppression of 'frontal arms' make it difficult to distinguish the vertex, frons, and the post-clypeus regions. The frontal suture while represented by a small deep groove in between the eyes in *Deporaus marginatus* Pasc. is absent in *Cylas formicarius* Fabr.

The sutures and the sclerites of thoracic segments and their appendages have been described in detail. The hind wings of the two species differ markedly in size, venation and texture. They are oblong and truncated at the apex. The wing has lost some of the principal veins in corelation with the complex folding. The wing folding in *Cylas formicarius* differs from all the types described by Graham (1922) and Forbes (1922) in their studies of wing venation of Coleoptera. The mechanism of wing articulation is quite simple. These are three axillary sclerites situated along the lateral margin of the notum. They are distinct in *Cylas formicarius* but in *Deporaus marginatus*, the first and the second axillary sclerites have fused forming a single large sclerite.

The external morphology of the abdominal segments and the male and female genitalia of the two species have been studied. In the studies of the male genitalia the terminology of Sharp and Muir has been followed. The male genitalia is a long slender tube with thick walls extending from the junction of the vasa-deferentia to the internal sac. The length of the internal sac is indicated by the length of the ductus ejaculatorius, because when the former is everted, the end of the ductus ejaculatorius moves backwards so that the orifice lies at the apex of the everted sac. The median lobe is heavily sclerotised tube of varying shape with two struts at its apparently anterior end. These struts, according to Sharp (1918), are of considerable taxonomic importance, being very consistent in shape within a species. The sclerotisation forms a band round the median lobe and it has a median strut pointing cephalad. This sclerotised region is known as the tegmen, and jointly with the median lobe forms the aedeagus. The median lobe moves freely through the arch formed by the struts of the tegmen. The median strut is biforked in *Cylas formicarius* while in *Deporaus marginatus*, it is resent as one rod like structure. The basal plates and the sclerotised rod are present. The spiculum gastrale is biforked at the anterior extremity in *Deporaus marginatus* whereas in *Cylas formicarius* it is simple. Some morphologists consider the spiculum gastrale to have developed from the ninth sternite, but in the absence of ninth tergite and without further embryological evidence, this hypothesis is not acceptable. The spiculum gastrale serves to lend rigidity to the genital apparatus during copulation, and supports the base of the median lobe.

The female genitalia consists of coxites and styles. The coxites are small hollow triangular structures with a simple fold which gives rise to a suture. The stylus is a small rod like organ. The two coxites are joined by a thin membrane. The female genital orifice or vulva open between the coxites.

Histology of the alimentary canal of the larva

The histological structures of the alimentary canal of the larva of *Deporaus marginatus* has been discussed. The dilator muscles are directly attached to the intima passing outside through the circular muscle to be attached to the head capsule. No teeth or spines were observed in the intima of the oesophagus. The author agrees with Pradhan and is of the opinion that oesophageal valve is not a valve, but a fold as the secretion of the midgut passes into the foregut without any action being exercised by the valve. According to Snodgrass (1935) and Pradhan (1936) these valves shut off an annular space for the opening of these glands are prevented from being clogged by the food contents, does not seem plausible. There does not appear any question of the clogging of the openings of the gastric caeca by the food material as the latter is almost always found near the opening of these glands and secondly the epithelial cells of the anterior portion of the midgut do pour their secretion in the space enclosed by the folds of this so called valve. This clearly shows that the oesophageal valve does not perform this function.

The reassociation of the malpighian tubules has been studied. Just above the junction between the colon and the rectum, the circular muscles of the colon end, and at this region the fascial chamber round the malpighian tubules communicates with the cavity of the gut by very minute pores which lead into minute canaliculi. The intima at this region is very thin and broken which indicates the presence of these pores.

Nervous System

The nervous system of the larvae and the adults of the two species have been described in detail. The nervous system is composed of the brain or supra-oesophageal ganglion, the sub-oesophageal ganglion, thoracic and abdominal ganglion. The brain is bilobed with a narrow apex in front and lie along with the sub-oesophageal ganglia in the head capsule. The ventral nerve cord consists of three thoracic ganglia, each supplying a pair of nerves. The abdominal ganglia are five in number in the larva and supply nerves to the anterior and posterior portions of the abdomen. In the adult the abdominal ganglia is elongated and bears a constriction in the middle to give the appearance of two ganglia. It gives out three pairs of nerves from its sides which supply the body wall, muscles of genital segment, reproductive organs and the hindgut.

Reproductive organs

The reproductive organs of the male and the female of the two species have been described.

The male reproductive organs occupy nearly the whole length of the abdomen. The two testes lie one on either side of the abdominal wall, being coiled with a pair of accessory glands. The accessory glands are long, tubular and open into the vasa-deferentia just above the seminal vesicles. The vasa-deferentia arises from the centres of each testes and runs for a short distance before uniting to form a common ejaculatory duct. It passes forward through the genital tube and terminates at the tip of the chitinous median lobe or aedeagus.

The female reproductive organs consist of paired ovaries, paired oviducts, a median duct, bursa-copulatrix and spermatheca and its duct.

INORGANIC ACID TEST FOR POLLEN VIABILITY

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In modern plant breeding the correct determination of number of viable and non-viable pollen grains produced by a plant is very important. There are two common methods which are in use for this purpose ; (a) Staining pollen grains with acetocarmine or iodine solution ; (b) Germination of pollen grains in vitro (see Wulff & Maheshwari, 1937 ; Brewbaker, 1959).

In the first method the pollen grains which take a normal stain are considered to be viable, while the unstained or irregularly stained ones are regarded as non-viable. This is not so perfect as some of the pollen grains which still have some cytoplasm and therefore, take some stain, are not really viable. This is particularly so in case of mature grains with a thick and warty exine where the staining process usually fails to differentiate between the viable and non-viable pollen grains. The artificial germination of pollen grains is thus the only sure method for correct determination of the pollen viability. This technique is also handicapped because of two requirements : (1) The exact culture medium, in which the pollen grains will successfully germinate and grow, has to be determined ; (2) Granted that the exact culture medium is found out, it takes enough time for the pollen grains to germinate which might vary from a few minutes to several hours.

The present paper describes a very quick method for testing the pollen viability by the use of inorganic acids, particularly hydrochloric acid, which to the best of our knowledge is the first attempt of its kind.

In our studies on *Ipomoea crassicaulis* forms with homostylic and heterostylic flowers (Paliwal & Koul, 1961), we found that in the latter form the pollen grains got detached from the pollinated pistils placed in N HCl for hydrolysis, and settled at the bottom of the watch glass in the form of a white uniform mass. A microscopic examination of this white mass showed it to consist of pollen grains with long "tube" like structures. As we have reported elsewhere (see Paliwal & Koul, 1961), the heterostylic flowers of *I. crassicaulis* are self-incompatible and therefore, these pollen grains did not germinate on the stigma. Subsequently on putting the mature pollen grains of *I. crassicaulis* in a drop of N HCl we observed instantaneously a long "tube" arising out of each pollen grain. A close examination of these "tubes" stained with light green or aniline blue* revealed that they were devoid of any wall, and thus these tube like structures were formed by the cytoplasm oozed out of the pollen grain in the form of a narrow strip (Fig. 1). What evidently happens is that as soon as the pollen grains are dusted in hydrochloric acid the intine bursts and the cytoplasm starts exuding. The peripheral part of the exuded cytoplasm coagulates as soon as it comes in contact with HCl and, therefore, it continues to grow forward forming a long and thin tube like structure.

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*Cytoplasmic tubes stain extremely lightly with acetocarmine.

The most important point is that all pollen grains from one anther of *I. crassicaulis*[1] did not show the exudation of cytoplasm when put in this medium. Such pollen grains which did not show this exudation are non-viable as is conclusively proved by the following experiments.

(*a*) The mature and viable pollen grains of *I. crassicaulis* were stored for 2—4 days at room conditions by which time they had lost their viability. Such pollen grains, when placed in this medium, show no exudation of cytoplasmic tubes.

(*b*) The pollen grains of *Plantago ovata* which has both male fertile and male sterile forms were tested by this method. The pollen grains from male fertile form showed this type of exudation while those from male sterile form did not. This confirms that only perfectly viable pollen grains show the exudation of cytoplasm whereas the sterile and non-viable grains do not.

This HCl test has been applied by us to several groups of plants belonging to different genera and families. Curiously enough the pollen grains of all plants do not respond to this test. The following table gives a list of plants that were tried with HCl and that could thus be divided into different categories.

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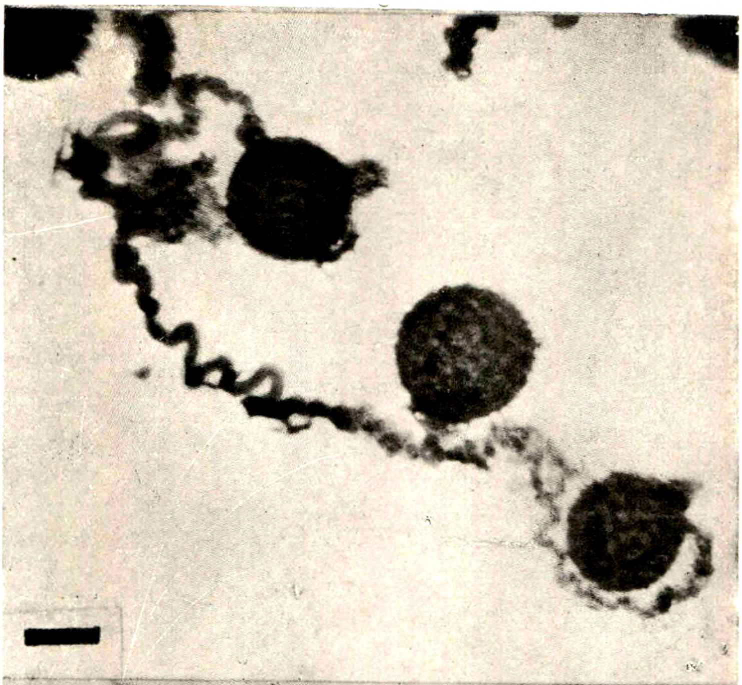
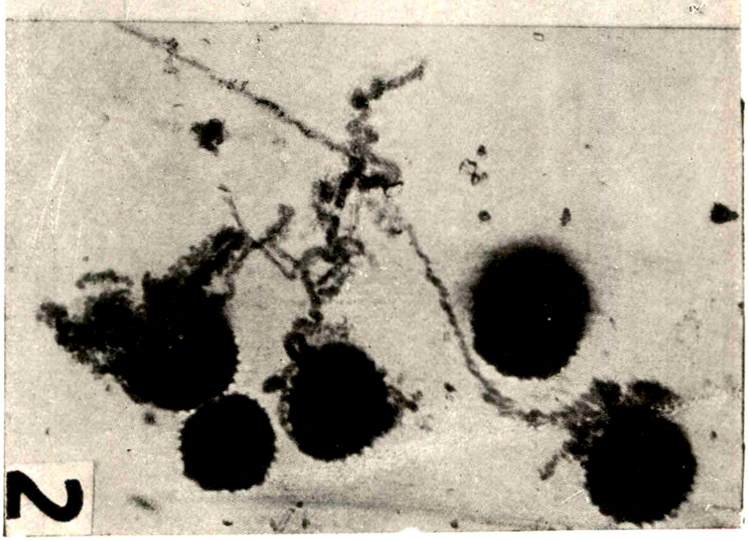
[1] *I. crassicaulis* shows 20—25% pollen sterility





EXPLANATION OF FIGURES

Fig 1. Showing "tube" like structures oozed out of the pollen grains of *Ipomoea crassicaulis* in N. hydrochloric acid X 190.

Fig 2. Showing "tube" like structures from pollen grains of *Gossypium hirsutum* in 1% hydrochloric acid X 114.

Plants that show exudation of cytoplasm in the form of tubes.	Plants that do not respond.
1. APOCYNACEAE	1. ACANTHACEAE
Thevetia neriifolia	*Adhatoda vasica*
2. CAESALPINIOIDEAE	2. CAESALPINIOIDEAE
Cassia occidentalis	*Delonix regia*
3. CANNACEAE	3. FLACOURTIACEAE
Canna indica	*Flacourtia sps*
4. CAPPARIDACEAE	4. GRAMINEAE
Crataeva religiosa	*Coix lacryma*
5. CONVOLVULACEAE	*Hordeum vulgare*
Ipomoea crassicaulis	*Triticum vulgare*
Ipomoea palmata	5. LILIACEAE
Convolvulus pluricaulis	*Lilium sps.*
6. LILIACEAE	6. MIMOSOIDEAE
Allium cepa	*Inga dulcis*
7. MALVACEAE	7. MELIACEAE
Althaea rosea	*Melia azadirachta*
Gossypium hirsutum	*Melia japonica*
Gossypium arboreum	
Hibiscus rosa-sinensis	
8. MIMOSOIDEAE	
Albizzia lebbek	
9. PLANTAGINACEAE	
Plantago ovata	
10. PEDALIACEAE	
Sesamum indicum	
11. SCROPHULARIACEAE	
Antirrhinum majus	
12. SOLANACEAE	
Nicotiana plumbaginifolia	
Petunia sps.	

The above list includes plants from several different categories *i.e.* monocots and dicots, perennials and annuals; trees, shrubs, herbs, and climbers and xerophytes as well as mesophytes. There is no unequivocal correlation between any one group of these plants and the response to the treatment. However, most of the monocots tried, excepting *Allium cepa* and *Canna indica*, did not respond to this test.

It is difficult to explain why the pollen grains of certain genera and families do not respond to this test while those of others do. Evidently there must be some mechanism in the pollen grains of these plants by which they evade this effect of N HCl. An increase in the concentration of HCl upto 10% did not have any effect in this group of plants.

In an acid medium as low as .0625% the exudation of cytoplasmic tubes is quite satisfactory. In majority of the cases 1% HCl produces most satisfactory results (Fig. 2). This means that exuded cytoplasm forms long tube-like structure. With an increase in the concentration of HCl the tube-like shape is disturbed. If the concentration is above 10% the pollen grains burst and fall into pieces. *Crataeva religiosa* was found to be the only exception among the plants tried, where exudation of cytoplasmic tubes started only in 10% HCl and not below it.

Other inorganic as well as organic acids were also tried to study their effects. These include sulphuric acid, nitric acid, lactic acid, acetic acid and propionic acid. None of the organic acids showed this effect. Both sulphuric and nitric acid on the other hand brought about the exudation of cytoplasm, but they proved to be drastic and the formation of cytoplasmic tubes was not as good as observed in pollen grains treated with hydrochloric acid. Funke (1956) has used concentrated sulphuric acid mixed with 2-3% methylene blue to study the number of germ pores in a pollen grain. When pollen grains are placed in this medium, he reports that cuticle of pollen pores is dissolved and cytoplasm emerges forming excrescences which are held in place by intine and by this means the number of germ pores can be determined.

It is, therefore, suggested that the hydrochloric acid test can be safely applied for viability and longevity of the pollen grains in such plants which respond to it. It appears to be particularly significant for such plants whose mature pollen grains have thick, warty and spiny exine which hinders in correct estimation of pollen viability by acetocarmine or iodine staining test.

SUMMARY

Use of inorganic acids, particularly hydrochloric acid, as a means of testing pollen viability and longevity has been described. The test has been employed in a wide variety of plants including monocots, dicots, perennials, annuals, xerophytes and mesophytes. The pollen grains of some genera do not respond to this test. Hydrochloric acid test is found to be of particular importance for pollen grains with a thick, warty and spiny exine.

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LITERATURE CITED

1. Brewbaker, J. L. 1969 Biology of the angiosperm pollen grain. Indian Jour. Genetics & Pl. Br. **19**: 121-133.
2. Funke, C. 1956 Emschnell methode Zur Slektion Polyploider Pflanzen (A rapid mathod for the selection of Polyploid Plants). Naturwissenschaften. **43**: 66.

3. Paliwal, R. L. & Koul, A. K. 1961 Cytological and pollination studies on two forms of *Ipomoea crassicaulis* (in press).

4. Wulff, H. D. & Maheshwari, P. 1937 Recent advances in microtechnique 1, Methods of studying the development of the male gametophyte in Angiosperms. Stain Tech **12**: 61-70.

INFLUENCE OF 2,4-DICHLOROPHENOXY-ACETIC ACID ON THE SEEDLING RESPIRATION OF MAIZE T, 41.

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Introduction

Bharadwaj and Rao (1955, 56) observed that the pre-sowing soaking of grains with 2,4-Dichlorophenoxy-acetic acid was helpful in improving the growth and maturity of wheat. Similar studies on maize were made by the authors and are reported elsewhere. In the present study, the influence of pre-sowing soaking of maize T. 41 grains in 2,4-Dichlorophenoxy-acetic acid at different concentrations for 24 hours was investigated on the respiratory activity of the seedlings, upto 72 hours, in order of find out the stimulating or inhibitive effect, if any.

Increase in the rate of respiration by 2,4-D treatment was reported by Brown (1946) in bean seedlings. Smith *et al* (1947) observed increased respiratory activity in rhizome and root slices of bindweed plants treated with 2,4-D. Similar observations were made by Lowell (1947), Kelley and Avery (1949) and Kalander and Numair (1954). However, contrary results were obtained by Taylor (1949) in wheat and mustard seedlings; and by Hsuch and Lou (1947) in rice and barley seedlings.

Methods and Material

Rate of respiration in terms of oxygen uptake was determined with the help of warburg's manometric technique. After preliminary experiments for the standardization of the technique the following procedure was adopted.

Grains of maize T. 41 were kept in large petridishes in contact with filter paper soaked in water or in solutions of 2,4-D (as the case may be) at about 30°C in a dark chamber. Grains soaked in the solutions were changed to distilled water after the treatment period *i.e.*, 24 hours. Uniform seedlings of the same age were selected from each treatment at intervals of 4 hours; they were weighed as usual before measuring their rate of respiration and the rate of uptake of oxygen was calculated in millilitres for one gram of fresh weight of the material in one hour and the results are summarised in table 1. Fresh KOH was filled in the central well of the Warburg flask before each observation. Duplicate flasks were kept for each of the treatments,

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O ppm, O. 1 ppm, 10 ppm and 100 ppm of 2,4-D along with six Thermobarometers (Three on each shaker) with altogether 14 flasks.

Six thermobarometers were arranged on the two shakers of the warburg's respiration apparatus (Gallenkamp model with rectangular tank) three on each side. Thermobarometer number 1 was parallel to 14, 4 parallel to 11 and 7 parallel to 8. During the experimental period, pressure differences in the manometers were greater between the adjacent Thermobarometers in the row than between the parallel ones. A maximum difference of 26 units of manometeric scale was observed between the row Thermobarometers while between parallel Thermobarometers a maximum difference of 9 units of manometric scale was noted for the duration of the observation period of 30 minutes (Two successive readings were taken at 15 minutes interval). It may be noted that even the maximum fluctuation in the Thermobarometers was relatively much lower than values for respiration. Still the values of the adjacent Thermobarometers were utilised for subtracting from the respective experimental values to get the actual values for Oxygen uptake by the respiring material.

RESULTS

Table I

Effect of 2,4-D (supplied during 0-24 hours, later replaced by distilled water) on rate of respiration of the seedlings of *Maize T. 41.*

(O_2 uptake in μ mls per gm. of fresh material weight per hour)

Time in hours after soaking	2,4-D concentration			
	0 ppm control	0.1 ppm.	10 ppm	100 ppm.
4	14.7	18.6	19.5	9.1
8	18.6	3.6	14.2	18.0
14	24.0	72.3	45.6	23.4
20	85.2	101.7	48.3	47.4
24	172.2	150.3	289.8	148.8
28	113.1	146.0	118.2	204.9
32	132.6	357.1	99.6	183.3
36	266.4	368.1	264.2	170.1
42	234.0	410.7	236.4	231.6
48	619.2	450.9	142.1	234.9
52	279.6	242.7	140.7	122.7
56	271.2	261.9	179.4	...
62	447.6	246.8	307.5	198.2
68	300.0	292.5	283.7	316.8
72	540.0	526.2	354.3	132.6

With a supply of distilled water (Control set-0 ppm of 2,4-D) the rate of respiration (0_2 uptake) was low during 0-24 hours, when the grains were getting soaked. With the sprouting of the grains the rate gradually went up reaching the maximum of 619.2 μ ml, (per gm. of fresh seedling per hour) by the end of the second day (48 hours); then the rate went down to a low level (279.6 μ ml.) but was going up soon during the third day; however, at 72 hours, it reached again a high value of 540.0 μ ml.

With a supply of the lower concentration of 2,4-D (0. 1 ppm) during 0-24 hours, the rate of respiration was higher than for the control set upto 42 hours; later on the rate remained lower than the control set but followed the same trend. At the end of the experiment (72 hours) it was 526.2 μ ml compared to 540.0 μ ml of the control.

With a supply of 10 ppm of 2,4-D during 0-24 hours the respiration was erratic and showed greater fluctuations in the rate than with the other treatments. During the first day, the rate was about the same as that of the control, except at 24 hours when the rate (289.6 μ ml) was much higher than the control (172.2μ ml). On the second day, the rate was gradually going down and was lower than the control. During the third day, the two curves (Control and 10 ppm) showed similar fluctuations and at 72 hours, the rate for 10 ppm was only 66% of the control.

With 100 ppm of 2,4-D supplied during 0-24 hours, the rate remained at a slightly lower level than the control upto 24 hours. On the second day, upto 32 hours, the rate was higher than the control. Later on, the curve went down and remained lower than the curves of the other sets except at 68 hours, when its rate went up unexpectedly, reaching almost the control vaule. However, at 72 hours, the rate was only 25% of the control. The following points from the results are noteworthy:

1. The curves in general do not show a smooth trend throughout the period of the experiment. Even the control curve is characterised by gradually rising peaks and slopes; occasionally an unusually high or low value is also observed; the latter perhaps is due to experimental error but the gradual rises and falls on each day of 24 hours may perhaps be characteristic of the respiratory phenomenon when studied at short intervals.

2. Pre-sowing soaking treatment with 0.1 ppm of 2,4-D seems to stimulate respiration both during the treatment period as well as later on. The stimulation is conspicuous upto the second day of the experiment (upto 42 hours). The later depression was fairly small.

3. Treatment with 10 ppm of 2,4-D shows apparent stimulation only upto 24 hours and later on it inhibits respiration. 100 ppm of 2,4-D inhibits respiration both during the treatment period (0-24 hours) as well as later on, and the effect is intensified gradually.

DISCUSSION

To begin with, it is necessary to point out that in the present study the effect of 2,4-D on respiration was studied during the initial treatment period of 24 hours; further its residual influence of after-effect upto 72 hours (including the treatment period) was also investigated. The results of other workers reviewed in the beginning relate mainly to the effect or 2,4-D on respiration when the chemical is sprayed over the foliage. A few workers studied the effect of the Chemical on respiration of stems or shoots of seedlings but, the experimental period was not extended. Warburg's technique was followed by only a few workers. Thus it becomes difficult to compare the results of the present study with those of other workers except in a general way. The stimulating or the inhibitive effect of the different concentrations of 2,4-D, tried in the present experiment, are brought out clearly in Table No. 2. where average rate of respiration for each day of the experiment is expressed as percentage of each treatment on the respective control.

Table II

Influence of 2,4-D on rate of respiration by maize T. 41 seedlings. (Daily averages for treatments expressed as percentages on control.)

Days	Concentration		
	0.1 ppm	10 ppm	100 ppm
1st day	112.8	133.5	78.8
2nd day	134.6	64.6	76.9
3rd day	90.8	68.8	52.4

It is clear that with the lowest concentration respiration was stimulated even during the treatment period (0-24 hours) and the effect increased on 2nd day when the average rate of respiration was 34.6% greater than the control. On the 3rd day, however, the inhibitive effect started and the average rate was 9.2% lower than the control. Thus the stimulative effect faded away with the lapse of time.

With the higher concentration of 10 ppm, stimulation was observed only on the 1st day; the average rate of respiration being 33.5% greater than the control. The inhibitive effect started immediately and at the end of second day there was a fall in the respiration rate by 35.4% compared to the control but at the end of the 3rd day the respiration rate was lower by 31.2% only compared to the control. Thus there was a clear tendency for the recovery even in such a short period of experimentation. With the still higher concentration of 2,4-D (100 ppm) respiration was retarded even during the treatment period, the rate being 21.2% lower than the control. With the supply of distilled water from the second day onward the inhibitive effect remained almost the same on the second day but the average rate for the 3rd day was only 52.4% of the control.

Kelley and Avery (1949) studied the Q_{02} (Oxygen uptake) of pea stem and oat coleoptiles over a period of 4 to 6 hours with a supply of different concentrations of 2, 4-D. The rate was measured in cubic millimeters of oxygen per hour for 30 segments. Either under starved or unstarved conditions, the average rate for the whole period of experimentation (4 to 6 hours) was higher than the control by 29 to 53% with 20, 50 or 100 ppm. The stimulating effect apparently increased with the concentration; only with 1000 ppm there was an inhibition by about 45% both in pea and in oats. They mentioned that the threshold concentration for stimulation was much lower for pea than for oats.

Although the conditions of experimentation as well as the material are different in the present experiment, it is to be noted that the stimulating effect was obtained once with 0.1 ppm and 10 ppm of 2,4-D.

In Pisum, Kelley and Avery observed an increase in respiration by 30 to 42% with 2,4-D at 0.001 ppm to 1 ppm; however, with oat coleoptile the stimulation started only at 1 ppm and it was only 15%. In the present study during the treatment period (0 to 24 hours) germinating grains of maize showed a stimulation of only 12% with 0.1 ppm and 33.5% with 10 ppm. Thus it is evident that 2,4-D at a suitable concentration may stimulate respiration even of germinating seeds, although the minimum concentration for stimulation as well as the amount of stimulation may vary with the type of material as well as the stage of growth. The inhibitive concentration (1000 ppm) observed by Kelley and Avery is much higher than that (100 ppm) noted in the present study. This difference again can be attributed to the difference in plant material and other conditions.

Respiration studies for the effect of 2,4-D were also carried out elsewhere when the chemical was sprayed. The results indicated evidently the after-effect of the spraying. Brown (1949) observed significantly greater respiration for four successive days after Bean plants were sprayed wih 1000 ppm of 2,4-D; similar stimulative after-effect was noted in the present experiment with 0.1 ppm but it extended only upto one day after the treatment. With the higher concentrations of 10 and 100 ppm there was no stimulating after-effect. The difference in the results can be attributed perhaps to the technique of application of the chemical and also to the difference in plant material and the stage of growth.

In the above discussion a detailed comparison of the present data has been made with only two investigations *i. e.*, of Kelley and Avery (1949) and Brown (1946). The stimulating effect of 2,4-D on respiration observed in the present studies also confirms the results of other workers (Smith *et al.* 1947, Lowe ll 1947, Kalander and Numair 1954 etc.).

The inhibitive effect observed by Taylor (1949) for respiration of wheat and mustard seedlings with 10 ppm of 2,4-D is also confirmed by the present results on maize wherein the rate went down by 35.4% on the second day and by 42.1% on the 3rd day. Hsuch and Lou (1947) observed an inhibition of 33% in the respiration of rice and barley seedlings on the first day by 2,4-D at 1000 ppm. With 100 ppm the respiration of maize seedlings went down to 47.6% on the 3rd day.

Thus the results of the present study agree in general with the stimulating and inhibitive effects of 2,4-D (at different concentrations) on respiration noted by other workers with different plant materials.

SUMMARY AND CONCLUSIONS

Effect of three concentrations of 2,4-D (0.1, 10 and 100 ppm) was studied on the rate of respiration of maize T. 41 seedlings from 0 to 72 hours, continuously at short intervals. The treatment was given during the first 24 hours (0 to 24 hrs.) and the seeds were germinated in a dark chamber at 30°C. Rate of respiration was measured as oxygen uptake by 1 gram of fresh material per hour with Warburg's respiration apparatus. The following conclusions are drawn:-

1. The lowest concentration of 2,4-D (0.1 ppm) stimulated respiration up to the 2nd day; it was inhibitive on the 3rd day.

2. A supply of 10 ppm of 2,4-D stimulated respiration only up to 24 hours after which the rate of respiration is to cut down.

3. The highest concentration of 2,4-D (100 ppm) retarded respiration from the very beginning and remained as such up to the end of the experimentation period.

4. The curves do not show a smooth trend throughout the period of the experiment. Even the control curve shows gradual rises and falls on each day which may perhaps be characteristic of respiratory phenomenon when studied at short intervals.

REFERENCES

1.	Bharadwaj, S. N. & I. M. Rao.	1955	Studies on the effect of 2,4-D, NAA and IAA on growth and maturity of wheat. Jour. Indian Bot. Soc. **34**: 21-28.
2.	Bharadwaj, S. N. & I. M. Rao.	1956	Influence of time of sowing on the effect of 2,4-D on growth and maturity of wheat. Physio. Plant. 9. 257-264.
3.	Brown, J. W.	1946	Effect of 2,4-D on the water relations, the accumulation and distribution of solid matter and the respiration of Bean plants. Bot. Gaz. **107**: 232-343.
4.	Hsuch, Y. L. & C. H. Lou	1947	Effects of 2,4-D on seed germination and respiration. Science **105**: 283-285.

5. Kalandar, Otto & Herbert Numair 1954 On the influence of 2,4-D on the metabolism of asparagus shoots grown in Vitro. Flora **141**: 16-29.
6. Kelley, S & G. S. Avery 'Jr' 1949 The effect of 2,4-D and other physiological active substances on respiration. Amer. Jour. Bot. **36**: 421-426.
7. Krebs, H. A. 1951 Improved manometeric fluid. Biochem. Jour. **48**: 241.
8. Lowell, W. R. 1947 The physiological action of 2,4-D on Dandalion, *Taraxacum officinale*. Plant Physiol. **22**: 377-392.
9. Smith, F. G., C. L. Hamner & R. F. Carlson. 1947 Changes in food reserve and respiratory capacity of bindweed tissues accompanying herbicidal action of 2,4-D Plant, Physiol. **22**: 58-65.
10. Taylor, D. L. 1947 Effect of 2,4-D on gas exchange of wheat and mustard seedlings. Bot. Gaz. **109**: 162-176.
11. Umbriet, W. W., R. H. Burries & J. F. Stanffar. 1949 Manometeric techniques and tissue metabolism.

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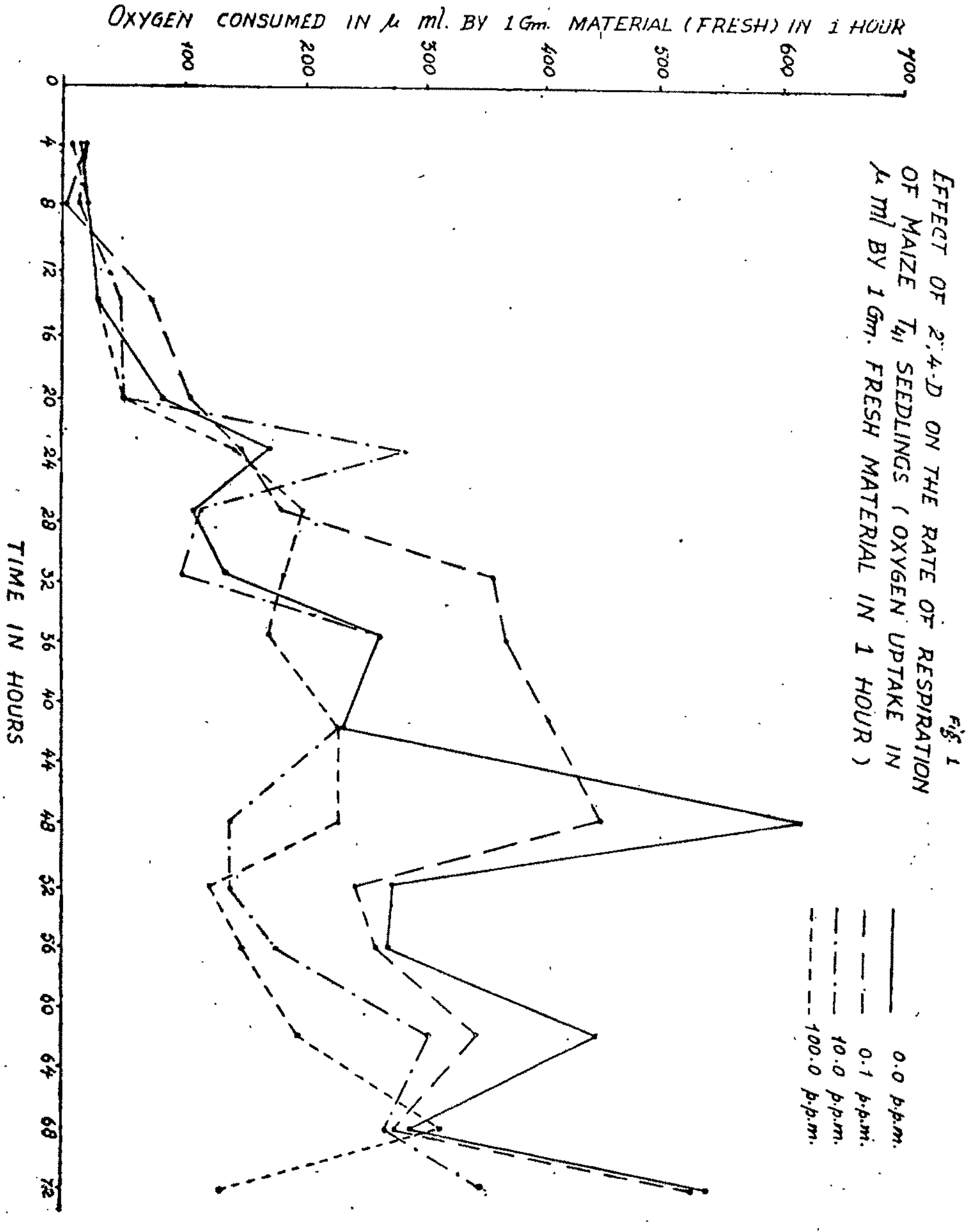

Fig. 1

EFFECT OF 2,4-D ON THE RATE OF RESPIRATION OF MAIZE T_{41} SEEDLINGS (OXYGEN UPTAKE IN μ ml BY 1 Gm. FRESH MATERIAL IN 1 HOUR)

INFLUENCE OF THE APPLICATION OF UREA, SUCROSE AND HORMONES ON THE CARBON-NITROGEN RELATION IN COTTON PLANT AND ITS BEARING ON BOLL SHEDDING*

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Summary and Conclusions

1. Cotton plant was selected for the present study on account of its economic value, and investigations were carried out on two species—*Gossypium hirsutum* var. L. S. S. an American and *Gossypium arboreum* var. 35/1, a desi cotton during the years 1956, 1957 and 1958.

2. *G. arboreum* var. 35/1 was sown in 2nd week of April and *G. hirsutum* var. L. S. S. in the 3rd week of June each year in pot cultures.

3. Eleven treatments were included : spraying nutrient chemicals—Urea (1%), sucrose (20%), urea (1%) and sucrose (20%) in combination; growth promoting substances—2,4-D (5ppm), NAA (20ppm), NOA (20ppm) and IAA (30ppm), and growth inhibiting substances—TIBA (40ppm) and trans Cinnamic acid (20ppm), distilled water besides unsprayed control. Spraying was done at a young seedling stage in 1956 and at the 4-leaf stage in the subsequent years, *i. e.*, nearly 3 weeks after sowing. In 1956 2,4-D was sprayed thrice and the others 6 times at fortnightly intervals, but in 1957 and 1958 only one spraying was done. Moreover, the number of treatments in 1958 was reduced from 11 to 8 eliminating NAA, TIBA and Urea-sucrose (combined).

4. Weekly observations on growth, flowering, fruiting, yield and chemical composition of leaves were made, starting from the day of treatment upto 19 weeks after spray.

5. Vegetative growth was measured in terms of (*i*) Mainstalk height, (*ii*) Mainstalk nodes, (*iii*) Mainstalk leaves, and (*iv*) Vegetative branches more than 20 cm. long.

6. Flowering was measured by (*i*) Flowers formed, (*ii*) Flowers retained, (*iii*) Flowers shed, and *Fruiting* by, (*i*) Bolls formed, (*ii*) Bolls retained, and (*iii*) Bolls shed.

7. The yield observations comprised of (*i*) Boll No./plant, (*ii*) Weight of seed cotton/plant, (*iii*) Weight of seed cotton/boll (*iv*) Seed number/plant,

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* This is an abstract of the thesis submitted for the Ph. D. degree of the Agra University in the year 1959-60.

(*v*) seed weight/plant, (*vi*) 100-seed weight, (*vii*) Lint weight/plant, (*viii*) Fiber length and (*ix*)—Ginning percentage.

8. Weekly analyses of mainstalk leaves for total available carbohydrates and total nitrogen were made. Middle third mainstalk leaves in var. 35/1 and upper third in var. L. S. S. were utilised for analyses.

9. The data on growth, flowering, and fruiting were statistically analysed on factorial basis. In yield, simple analysis of variance based on a single factor was calculated. The percentages of total available carbohydrates and total nitrogen were calculated on dry weight basis.

10. The meteorological observations comprising of Max. and min. temperature, Relative humidity and Rainfall for the dates on which observations were made in the 3 years were obtained from the local observatory under the supervison of the department of chemistry, Meerut College.

11. The data on growth, flowering, fruiting, yield, chemical composition, and also the relation of the chemical composition with boll shedding and meteorological observations have been represented either by graphs or histograms.

12. The general growth of the plants was affected by the nutrients, auxins and anti-auxins. The urea treated plants were generally shorter and the sucrose treated ones taller than the untreated controls. The number of mainstalk nodes was, however, more in the urea treated ones showing thereby that the internodes were short. It also caused burning patches on the leaves. The 2,4-D, NOA and IAA treated plants were generally short and bushy with more of vegetative branches. The node number, phyllotaxy and the shapes of leaves were altered by 2,4-D. The leaves showed epinasty, curling, bending, condensation of veins and also became hard, brittle and narrow. This was so for the leaves which were either present on the plant or were in a stage of initiation at the time of spray. The effect persisted for long in 1956 when 3 sprayings were done but lasted for only 8 weeks in the subsequent years when only one had been done. The new leaves, thereafter, were normal. Mild epinasty and condensation of veins were also caused by NOA, but the other treatments did not cause any morphological change. However, TIBA sprayed leaves were thick and dark green in colour.

13. The nutrients especially sucrose caused general improvement in the growth of the plants which resulted in early flowering and fruiting, but the number of flowers and bolls formed, retained and shed were generally lower than the controls, except in 1956 when boll formation and retention were significantly higher.

14. A single spray resulted in the formation of a significantly higher number of flowers in all the auxin treatments. Flower retention was high

in 2,4-D, NAA and NOA, but low in IAA. Shedding was also more in all auxin treatments.

15. A single spray of CA resulted in the formation and retention of a small number of flowers, but shedding was more. TIBA caused more formation, retention and shedding of flowers.

16. Six sprays of the auxins significantly increased boll formation, retention and shedding, but a single spray did so only in 2,4-D, NAA and NOA. IAA reduced the number.

17. The weight of seed cotton per plant was increased by sucrose and CA treatments in var. L. S. S., and by urea, sucrose, 2,4-D, NOA and IAA in var. 35/1. The seed number per plant was increased only by 2,4-D in var. L. S. S., but by all the nutrient, auxin and anti-auxin treatments in the desi variety. The seed weight/plant was decreased by all the treatments in var. L. S. S. and by CA in var. 35/1. More lint/ plant was produced by the sucrose and CA treatments in var. L. S. S. and by all the treatments except CA in the other variety.

18. The total available carbohydrates were decreased by the auxins and anti-auxin treatments for a few weeks after the spray. Later the age and climatic effects were more dominant.

19. As inconsistent values for total nitrogen were obtained a few weeks after spray of the chemicals and hormones, nothing definite can be said about their effect on the total nitrogen of the leaves.

20. In both varieties, active bolling and shedding were associated with large decreases in carbohydrates and nitrogen of the leaves in all the nutrient, auxin, anti-auxin treatments and also in the controls.

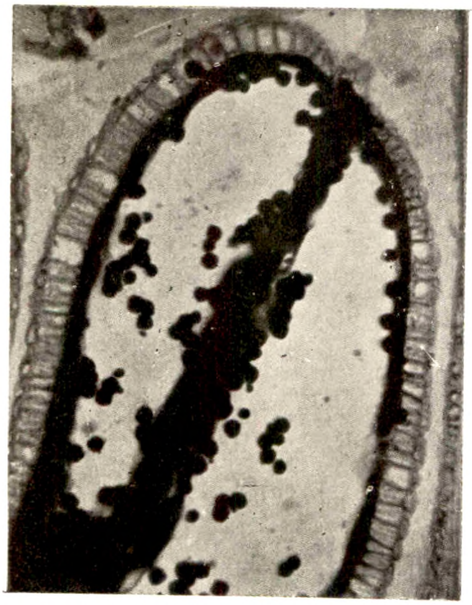
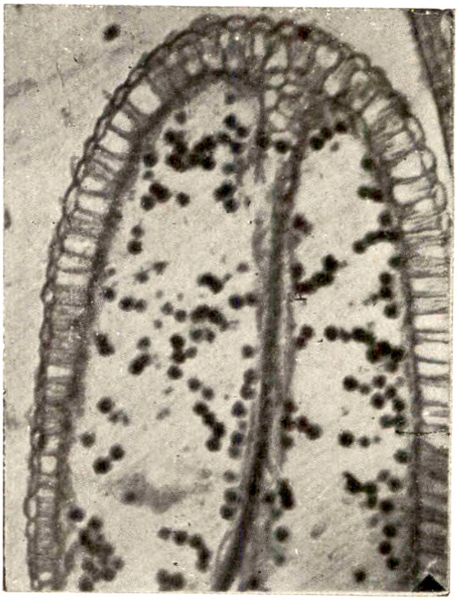


Fig. 1.



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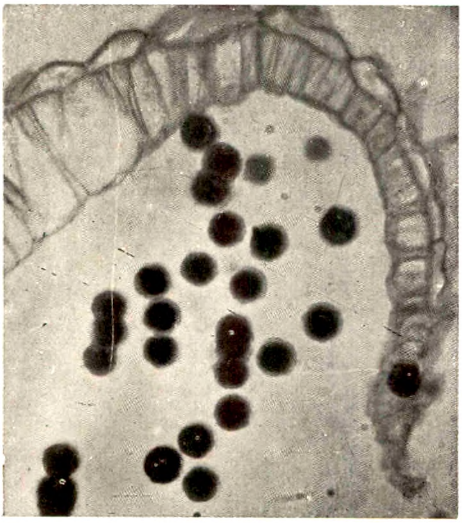

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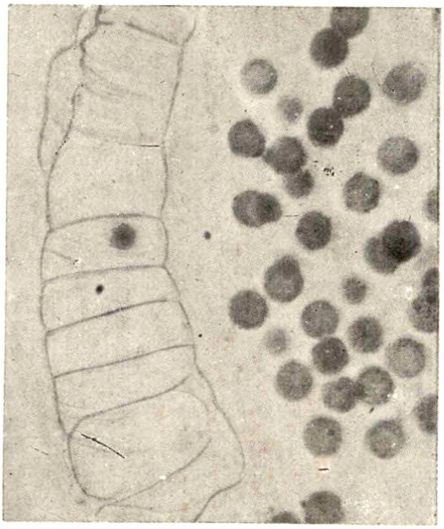

Fig. 4.

LOCALIZATION OF ACID PHOSPHATASE IN THE ANTHERS OF ANTIRRHINUM ORONTIUM LINN.

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The present investigation, on the localization of acid phosphatase in the anthers of *Antirrhinum orontium*, was undertaken to study the distribution of enzymes in different wall layers and microspores at different periods of their growth. Cytochemical method of Glick and Fisher (1945) with a modification of Wilson and Cutter (1955) was used. Figures 1 and 3 are controls (*i. e.*, the slides have been treated with the incubation medium without sodium glycerophosphate), while the figures 2 and 4 represent those slides which are treated with the incubation media containing sodium glycerophosphate. In the text, figures of the materials of approximately of the same stage of control as well as treated have been referred together to show the specificity of the reaction.

In young anthers the enzyme activity is mostly localized in the nuclei of the sporogenous cells. By the time meiotic divisions are over, intense activity of the enzyme is seen in the tapetal layer (Fig. 1 & 2). The microspores on separation gradually become rich in enzyme content and the mature pollen grains give intense colouration after treatment (Figs. 3 & 4). The activity of acid phosphatase appears to be related to the development of microspores and their further differentiation into mature pollen grains.

Acid phosphatase has also been localized in the differentiating vascular tissue of the anthers. A report of similar enzyme activity in the differentiating vascular tissue has been reported in Cucurbitaceous fruits by Wilson (1949).

Literature Cited

1. Glick, D and Fisher, E. E. 1945. Studies in Histochemistry XVI. Methods of histochemical localization of adenosinetriphosphatase, thiaminepyrophosphatase in grains and sprouts. *Arch Biochem.* **8**: 91-96.
2. Wilson, K. S. 1949. Histochemical localization of acid phosphatase during development of cucurbit fruits. *Amer. J. Bot.* 36: 806-807.
3. Wilson, K. S. and Cutter, V. M. (Jr). 1955. Localization of acid phosphatase in the embryo sac and endosperm of *Cocos nucifera*. *Amer. J. Bot.* **42**: 116-119.

Legend

Figs. 1-4. Sections of anthers.
Fig. 1. Control, without Sodium glycerophosphate. X 140.
Fig. 2. Treated, with Sodium glycerophosphate. X 140.
Fig. 3. Control. X 225.
Fig. 4. Treated. X 225. Note deep black colouration in the pollen grains.

MALON-*O*- AND *P*-CHLORANILIC ACID HYDRAZIDES AS REAGENTS FOR CARBONYL COMPOUNDS

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Acid hydrazides have gained some degree of notoriety through the use of certain members of the group in the treatment of tuberculosis. The best known is isonicotinic hydrazide. Recently cyanacethydrazide has been used in the treatment of husk or lungworm in animals (2). This has again pointed to the value of acid hydrazides in chemotherapy. Maleic hydrazide is now established as a plant growth regulant (4, 5). Further, acid hydrazides find important use as intermediates in the synthesis of a large variety of heterocyclic compounds, hydrazones, acid azides, isocyanates, amines, urethanes and ureas. They can also be used in the synthesis of aldehydes (3).

So it was thought worthwhile to prepare a new series of acid hydrazides and study their properties and uses. Hydrazides of malonanilic, malon-*o*-, *m*- and *p*- toluidic and malon-*o*-, *m*- and *p*-chloranilic acids were prepared in this laboratory recently (1).

This paper embodies the results of the investigations done in continuation of the above work. Malon-*o*-chloranilic acid hydrazide and malon-*p*-chloranilic acid hydrazide have now been used to prepare hydrazones from several aldehydes. This was undertaken to find out whether these can be used as reagents for the detection and identification of carbonyl compounds. The hydrazones of the following aldehydes were prepared and identified; the three mononitro benzaldehydes, vanillin, veratraldehyde; piperonal, 5-chloro, 3:5-dichloro, 5-bromo, 3:5 dibromo, 3-nitro, 5-nitro, 5-chloro-3nitro-salicylaldehydes and 2-methyl-4-(NN-bis-2′cyanoethyl) aminobenzaldehyde. The last mentioned aldehyde was prepared for the first time in this laboratory and the details are under publication.

The results obtained are very encouraging. The hydrazones are easily formed in high yields at room temperature and are almost colourless crystalline compounds. The use of these acid hydrazides in the preparation of acid azides, heterocyclic compounds etc. are under investigation.

EXPERIMENTAL

Preparation and purification of the acid hydrazides have already been described(1). The method of procedure for the preparation of the hydrazones was the same in all cases. To 0.5 g. of the acid hydrazide dissolved in 10 ml. of ethanol was added an equimolecular qunatity of the aldehyde dissolved in the minimum of alcohol. The mixture was gently warmed for a minute, and then set aside at room temperature for 30 minutes. The crystals which started separating immediately after the components were mixed were now filtered, dried and recrystallised from alcohol. The yield, m. p. etc. of the hydrazones obtained are given in the accompanying table.

Table giving the m. p. yield etc. of the hydrazones

No.	Hydrazone	Mol. Form.	M. P.	Yield%	Nitrogen%	
					Found	Required
1	X-*o*-nitrobenzaldehyde	$C_{16}H_{13}N_4O_4Cl$	227	83	12.41	12.12
2	X-*m*-nitrobenzaldehyde	$C_{16}H_{13}N_4O_4Cl$	197	67	12.5	12.12
3	X-*p*-nitrobenzaldehyde	$C_{16}H_{13}N_4O_4Cl$	218	76	11.8	12.12
4	X-vanillin	$C_{17}H_{16}N_3O_4Cl$	184	79	11.93	11.65
5	X-piperonal	$C_{17}H_{14}N_3O_4Cl$	197	74	12.41	12.09
6	X-veratraldehyde	$C_{18}H_{18}N_3O_4Cl$	176	94	11.39	10.95
7	Y-*o*-nitrobenzaldehyde	$C_{16}H_{13}N_4O_4Cl$	209	74	12.38	12.12
8	Y-*m*-nitrobenzaldehyde	$C_{16}H_{13}N_4O_4Cl$	218	78	12.24	12.12
9	Y-*p*-nitrobenzaldehyde	$C_{16}H_{13}N_4O_4Cl$	130	90	12.35	12.12
10	Y-5-chloro-salicylaldehyde	$C_{16}H_{13}N_3O_3Cl_2$	213	70	11.01	11.48
11	Y-3:5-dichloro-salicylaldehyde	$C_{16}H_{12}N_3O_3Cl_3$	117	66	10.1	10.49
12	Y-5-bromo-salicylaldehyde	$C_{16}H_{13}N_3O_3ClBr$	213	87	10. 5	10.03
13	Y-3:5-dibromo-salicylaldehyde	$C_{16}N_{12}O_3N_3ClBr_2$	242	82	9.04	8.58
14	Y-3-nitro-salicylaldehyde	$C_{16}H_{13}N_4O_5Cl$	217	81	14.96	15.49
15	Y-5-nitro-salicylaldehyde	$C_{16}H_{13}N_4O_5Cl$	154	90	15.16	15.49
16	Y-5-choloro-3-nitro salicylaldehyde	$C_{16}H_{12}N_4O_5C_2$	212	71	13.85	13.63
17	Y-2-methyl-4-(NN-lis-2′-cyanoethyl) amino-benzaldehyde	$C_{23}H_{23}O_2N_6Cl$	215	73	15.5	15.48

X—stands for malon-*o*-chloranilic acid hydrazone of

Y—stands for malon-*p*-chloranilic acid hydrazone of

REFERENCES

1. Brijraj Singh Rathore and P. I. Ittyerah; *Jour. Indian. Chem. Soc.* 1960, **37**, 591.
2. 'Financial Times' 28th May, 1957.
3. Mc Fadyen, J. S. and T. S. Stevens, *J. Chem. Soc.* 1936; 584.
4. Schoene, D. C. and O. L. Hoffmann, *Science* 1949, **109**, 588.
5. Zukel, J. W., *Agric. Chemic.*, 1954 **10**. 46.

PROPAGATION OF KAGZI LIME (*Citrus Aurantifolia Swingle*) BY SOFTWOOD CUTTINGS

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Kagzi lime is very shy to root from hardwood cuttings (1). Garner (3) reported that many shy rooting plants could be successfully propagated from softwood cuttings. Such cuttings, however, need very careful nursing and should be planted under high humidity. At this research station very encouraging results have been obtained by planting kagzi lime softwood cuttings under polythene covers in partial shade of lath house (2, 6).

Youngest tip cuttings are endowed with the greatest rooting potential, and with increase in age of the source shoots as well as of mother plants the rooting capacity of the cuttings decreases (7). Even in the same season with advancement of time the shoots get harder and thus gradually loose their rooting potential, but their capacity to survive improves. Softwood cuttings should, therefore, be taken when, apart from the suitability of the weather conditions, they are hard enough to survive for sufficient period and yet have retained as much of their rooting capacity as possible. This paper describes the results of an experiment to find out the best compromise between these two opposing factors in two planting environments.

Materials and Methods

Softwood cuttings of this experiment were obtained from 2 year old nursery plants and an 8 year old bearing tree. The length of the cuttings was about 3.5″ and they were planted after removing the lowest 3 to 4 leaves in 2.5″×2″ earthen pots filled with river sand and sieved leaf mould in equal parts by weight on four dates at fortnightly intervals from July 12, 1959. The pots were kept in partial shade of lath house with and without polythene covers which were made by fixing 500 gauge polythene over 4′×2.5′×2′ wooden frames.

The design of layout was systematic and randomised with four replications. Fifteen pots with one cutting each formed a plot. Five of these pots were used for periodical observations and ten were finally recorded eight weeks after planting. The rooted cuttings after final study were transplanted in 7″×4″ pots and slowly hardened before planting in open beds.

Results

Survival, rooting and establishment of cuttings :

It was observed that a number of cuttings died even after rooting, but once they were able to sprout, there was no further death of the cuttings that had rooted and sprouted which gave the percentage of cuttings established into new plants. The data were, therefore, analysed statistically for the percentages of three types of cuttings *i. e.*, alive, rooted and established (alive with live roots and shoots). Only 25.6% of the cuttings planted in partial shade of lath house were able to establish into new plants even though 46.2% of them had rooted and 65% survived till the end (Table I). Provision of polythene covers in the lath house resulted in a very high increase in survival, rooting and establishment (79.6%, 81.9% and 64.7% respectively).

Table I

Effect of source, planting date and environment on survival, rooting and establishment of cuttings.

Treatments	Per cent alive	Per cent rooted	Per cent established
ENVIRONMENT			
Partial shade of lath house	65.0	46.2	25.6
Polythene covers in lath house	79.6	81.9	64.7
C. D. at 1%	8.1	9.0	7.8
DATE			
July 12	97.5	93.7	80.6
July 26	77.5	70.6	53.7
August 9	66.9	51.2	18.7
August 23	47.5	40.6	27.5
C. D. at 5%	8.8	8.8	8.4
C. D. at 1%	11.7	12.8	11.1
SOURCE			
Young plants	81.2	69.1	53.7
Bearing trees	63.4	59.1	36.6
C. D. at 1%	8.1	9.0	7.8

The time of planting had a marked influence on the performance of the cuttings as represented by their survival, rooting and establishment. Planting in the second week of July proved to be the best in all these respects, since as high as 97.5% of the cuttings were alive at final recording, of which 93.7% had rooted and 80.6% had established into new plants. With delay in planting there was a marked reduction in the performance of these cuttings till at the last planting of August 23 the success was reduced to less than half.

Cuttings obtained from young plants showed a significantly higher percentage of survival, rooting and establishment as compared to those from bearing trees, but the latter also gave quite satisfactory results particularly in respect of rooting.

Of the three factors of this experiment the effect of environment of planting was most marked. The survival as well as establishment of the cuttings planted in two environments was very characteristic. The cuttings planted without polythene covers died at a much faster rate during the first fortnight after planting causing a difference of 17.1% between the two environments, but after this there was very little difference in their death rate (Fig. 1). In respect of establishment of cuttings, on the other hand, the difference between the two environments increased progressively upto final recording. Provision of polythene covers enabled 64.7% of them to establish as against 25.6% without these covers. The difference between the percentage of cuttings alive and established at final recording was also much marked when cuttings were planted without polythene covers.

The effect of dates of planting was very much marked when the cuttings were planted in the partial shade of lath house (Table II). The percentage of alive cuttings decreased from 96.2 to 26.2 when the planting was delayed from July 12 to August 23. On rooting and establishment the differences were still more marked, since in the former the reduction was from 87.5 to 8.7 and in the latter from 70.0 to just 1.2 between the first and last plantings. With the provision of polythene covers the difference between the dates of planting was much reduced. In this environment there was 100% rooting and 91.2% establishment when the cuttings were planted on July 12 and even in the last planting, rooting, and establishment were 72.5% and 53.7% respectively.

Table II

Percentage of cuttings alive, rooted and established as affected by the interaction between environment and date of planting

Environment	Planting dates	Per cent alive	Per cent rooted	Per cent established
Partial shade of lath house	July 12	96.2	87.5	70.0
	July 26	68.7	50.0	27.5
	August 9	68.7	38.7	3.7
	August 23	26.2	8.7	1.2
Polythene covers in lath house	July 12	98.7	100.0	91.2
	July 26	86.2	91.2	80.0
	August 9	65.0	63.7	33.7
	August 23	68.7	72.5	53.7
C. D. at 5%		12.4	13.5	11.6
C. D. at 1%		16.4	18.0	15.5

When the cuttings were planted on July 12, there was practically no difference between the two environments in the survival of cuttings. For rooting and establishment the differences between them increased. When the planting was delayed, the differences increased in respect of all the three characters and they were the maximum in the last planting.

Root and shoot characters :

Though all cuttings were finally recorded after eight weeks of planting and thus the time available for their growth was the same in all cases, the treatments of this experiment brought about considerable variation in the various root and shoot characters (Table III). Polythene covers proved much superior to partial shade alone for all growth characters and the cuttings taken from young plants were, on the whole, better than those from bearing trees. The number and length of roots were the maximum on the earliest planting date, and with delay in planting the results became poorer, but there was not much difference between the last two plantings in these respects. The effect of planting dates, was not so well marked on the various shoot characters, though it appeared that, on the whole, August plantings were slightly better than those of July.

Table III

Effect of environment and date of planting and source of cuttings on the various root and shoot characters.

Treatments	No. of roots per cutting	Length of the longest root in m. m.	No. of sprouts per cutting	Lenght of the longest sprout in m. m.	No. of new leaves per cutting
ENVIRONMENT					
Partial shade of lath house	3.42	82	1.33	29.0	2.4
Polythene covers in lath house	4.57	145	1.55	69.0	7.1
DATE					
July 12	5.25	152	1.35	66.3	4.8
July 26	3.55	117	1.38	46.0	4.9
August 9	3.37	94	1.65	46.3	5.6
August 23	3.85	94	1.61	54.6	7.1
SOURCE					
Young plants	4.25	116	1.63	59.9	6.3
Bearing trees	3.77	114	1.29	47.8	4.4

Discussion

The findings of this experiment have very clearly brought out the paramount importance of the planting environment for the success of kagzi lime softwood cuttings. Planting of these cuttings under polythene covers in the partial shade of lath house gave highly satisfactory results (over-all rooting 81.9% and establishment 64.7%, but when planted on July 12, 100% rooting and 91.2% establishment). These findings are in close conformity with those of Singh (6), who also found similar results from such cuttings planted during rains. Without polythene covers though 65% of the cuttings were found alive at final recording, only 46.2% had rooted and 25.6% were established into new plants. The rooting and shoot growth also started two weeks later in these cuttings. As observed by Johnston (5), the superiority of polythene covers appears to lie in high humidity under them with free exchange of gases and availability of some light.

The difference between the two environments was much less marked in the case of July 12 planting when even without polythene covers 70.0% cuttings established into new plants. With delay in planting the conditions became less favourable and the difference between the two environments increased and it was the maximum on the last planting date. The usefulness of polythene covers is, therefore, greater when the conditions are not so favourable. Even otherwise, provision of these covers would always be desirable since high humidity and frequent rains which were fortunately available to the cuttings planted on earlier dates in this experiment, would always remain beyond the control of the plant propagator.

The superiority of earlier plantings of this experiment was probably due to more favourable conditions of humidity and rainfall. 1959 was a year of abnormally low rainfall because of failure of rains in the later part of rainy season. The decline in the performance of the cuttings with delay in planting was perhaps also due to a gradual reduction in the vigour of the source shoots. All the cuttings of this experiment were taken from the same flush and therefore, with advance of time the source shoots became harder and consequently less vigorous. Singh, Garner and Hatcher (7) also found a decline in rooting of apple cuttings due to hardening of source shoots as the season advanced.

The performance of the cuttings taken from young plants was much better than that of those from bearing trees. This was mainly because of juvenility and greater vigour of the former source. With increase in age of the plants the vegetative vigour was reduced which was reflected in the rooting and sprouting of the cuttings. These results, thus, support the findings of Singh, Garner and Hatcher (8) who found a direct relation between the vigour of the source shoots and the rooting of apple leaf-bud cuttings. Garner and Hatcher (4) observed that decline in rooting in clone bore close resemblance to that found in seedlings, suggesting that root tissues when first initiated might have something of the quality of juvenility.

In the series of experiments on propagation of kagzi lime by softwood cuttings at this research station (Das *et al.*, 2; Singh, 6; and the present one) the influence of source of cuttings, planting season, time within the season, environment of planting and plant regulator treatments has been well studied and it has been shown that if the cuttings are taken in early part of the rainy season and planted under polythene covers in partial shade, almost cent per cent rooting and establishment may be obtained. Such cuttings did not benefit from plant regulator treatments and if they were planted at the proper time, their source was also not a very important factor. When the rooted and growing cuttings were planted in the nursery after gradual hardening, their performance was, however, not very encouraging even after giving due allowance for the disturbance due to washing of the rooting media for the study of various root characters. Their death rate was high and the growth of the surviving ones was not very vigorous. It appears that these cuttings need some special nursing even after rooting and sprouting and experiments on these lines are in progress with a view to standardize the technique for commercial adoption.

SUMMARY

Two planting environments, partial shade of lath house with and without polythene covers, were tested for their effect on kagzi lime softwood cuttings taken from young plants and bearing trees and planted on four dates at fortnightly intervals from July 12, 1959.

Planting of cuttings on July 12 under polythene covers in partial shade of lath house gave the best results (100% rooting and 91.2% establishment) but even without these covers the performance of the cuttings planted on this date was quite satisfactory (87.5% rooting and 70.0% establishment). With delay in planting the results became poorer in both the environments but the effect of less favourable weather was more marked when polythene covers were not used, which resulted in only 1.2% establishment of the cuttings of the last planting in this environment as compared to 53.7% under polythene covers. As a result of these differences the overall performances of the cuttings including various root and shoot characters under polythene covers was far superior to that without them. The difference between survival and establishment of cuttings under these covers was also much less marked.

Young nursery plants which were more vigorous and juvenile proved a much better source of cuttings than bearing trees in all respects but even with the latter source the results were quite satisfactory.

REFERENCES

1. Bhutani; J. C. and S. M. Singh, 1959. Influence of ringing the source shoots and plant regulator concentrations on the performance of hardwood cuttings of kagzi lime (*Citrus aurantifolia*, Swingle). *B. V. J. Agri. Sci. Res.* **1** (2): 13.

2. Das, D. N., B. Singh, G. N. Parida and R. P. Singh, 1959. Studies on the interplay of factors influencing the performance of sweet and kagzi lime cuttings. *B. V. J. Agri. Sci. Res.*, **1** (1): 16.
3. Garner. R. J. 1958. Propagation of woody plants by cuttings. Recent research and its application to fruit tree rootstocks. *J. R. Hort. Soc.*, **83** (8) : 335.
4. Garner, R. J. and E. S. J. Hatcher, 1958. Aspects of rootstock. propagation. V. The behaviour of root cuttings from plants of different age of establishment. *Rep. E. Malling Res. Sta. for* 1957 (1958):57.
5. Johnston, S. 1958. Investigations with plastic covers for blueberry propagating frames. *Quatt Bull. Mich. Agri Excp. Stat.*, **40** : 530.
6. Singh, R. P. 1959. Influence of indolebutyric acid and planting time on the performance of kagzi lime (*Citrus aurantifolia L.*) softwood cuttings. *Indian J. Hort.*, **16** (2) : 79.
7. Singh, S. M., R. J. Garner and E. S. J Hatcher, 1957. The behaviour of softwood cuttings of apple in the open under intermittent mist and in closed propagation frames. *J. Hort. Sci.*, **32** (4) : 240.
8. Singh, S. M., R. J Garner and E. S. J. Hatcher, 1957. The influence of source and environment on the performance of apple leaf-bud cuttings. *J. Hort. Sci.*, **32** (4) : 248.

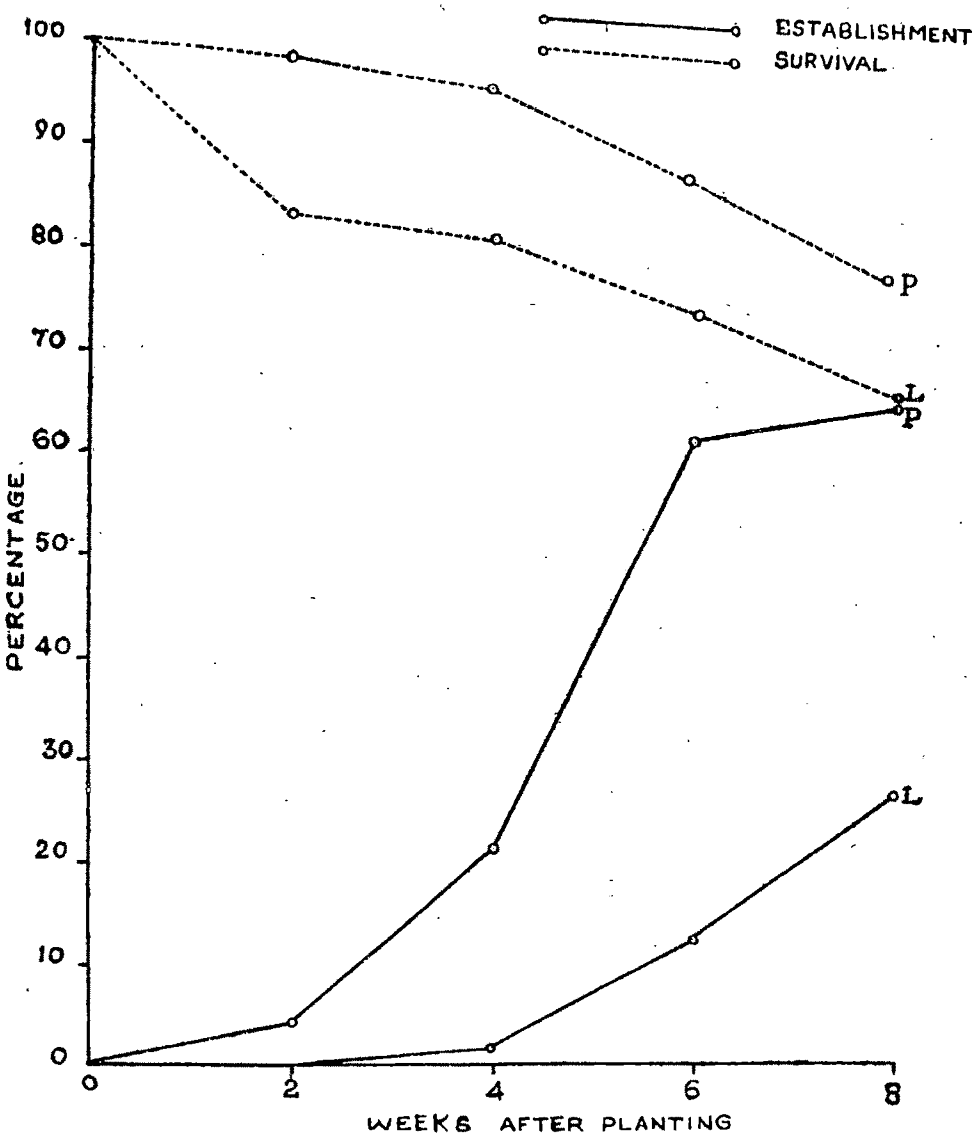

FIG.1– EFFECT OF PLANTING ENVIRONMEN ON THE SURVIVAL AND ESTABLISHMENT OF CUTTINGS

L = LATH HOUSE P = POLYTHENE COVER IN LATH HOUSE

STUDIES ON ENDOSPERM AND DEVELOPMENT OF SEEDS IN CUCURBITACEAE AND SOME OF ITS RELATED FAMILIES*

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The family Cucurbitaceae is predominantly tropical and has 100 genera containing about 850 species (Lawrence, 1951). There is great dispute regarding the systematic position of the family. De Candolle (1824-1873), Bentham and Hooker (1862-1883), Bessey (1915), Rendle (1925), Hutchinson (1926, 1959), Pool (1941), and Gundersen (1950) consider that it belongs to the Polypetalae; while Engler and Prantl (1889), Wettstein (1911, 1935), Engler and Gilg (1924), Janchen (1932), and Lawrence (1951) place it in the Sympetalae. Vuillemin (1923), however, regards that the family should be placed in Apetalae. The family has received considerable attention from workers in various fields. The embryological investigations are mostly confined to the origin and development of gametophytes. Only brief accounts regarding the development of endosperm and embryo are available (Kirkwood, 1905; Tillman, 1906; Kratzer, 1918; Souèges, 1939; and Chakravorti, 1947).

In recent years the family has received the attention of various workers (Chopra, 1953, 1954, 1955; Chopra and Agrawal, 1958; Johri and Roy Chowdhury, 1957; Singh, B., 1952, 1953; Singh, D., 1955a, b, 1956, 1957; and Weiling and Schagen, 1955). Singh, B., (1953) has drawn a close parallel of seed coat structure of Cucurbitaceae with Caricaceae, and has suggested that to establish this parallelism, it is necessary to work out the seed structure of Caricaceae and wrinkled seeds of Cucurbitaceae. Therefore, the present investigation has been taken up. It deals with the study of the structure and development of ovule, fertilisation, persistent pollen tube, endosperm, embryo, post-fertilisation changes in nucellus and the integuments together with the structure of mature seed.

The plants of Cucurbitaceae selected are *Citrullus colocynthis* Schrad., *Coccinia indica* W & A., *Ctenolepis cerasiformis* Naud., *C. garcini* Naud., *Cucumis melo L.* Var. *pubescens* Willd., *Cucumis sativus* L., *Cucurbita pepo* L., *Cyclanthera explodens* Naud., *C. pedata* Schrad., *Dicaelospermum ritchiei* Clarke, *Echinocystis wrightii* Cogn., *Edgaria darjeelingensis* Clarke, *Gymnopetalum cochinchinense* Kurz., *Herpetospermum caudigerum* Wall., *Luffa acutangula*[1] (hermaphrodite var.), *L. graveolens* Roxb., *Melothria maderaspatana* Cogn., *Momordica charantia* Linn., *Sechium edule* S. W., and *Trichosanthes cucumerina* Linn., and those of the related families are

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* Abstract of the thesis submitted for the Ph.D. degree of the Agra University (1959).

[1] This plant could not be conclusively identified at Kew and is, therefore, referred to as suggested by the then Director, Sir Edward Salisbury.

Carica papaya L. (Caricaceae), *Passiflora foetida* Linn. (Passifloraceae) *Viola tricolor* L., and *Ionidium suffruticosum* Ging. (Violaceae).

The material of *Cucumis sativus*, *Cucurbita pepo*, *Luffa acutangula* (hermaphrodite var.), *Carica papaya*, and *Viola tricolor* was collected from the Botanical gardens, B. R. College, Agra; of *Citrullus colocynthis*, *Cucumis melo* var. *pubescens*, *Coccinia indica*, *Ctenolepis cerasiformis*, *C. garcini*, *Melothria maderaspatana*, *Momordica charantia*, and *Ionidium suffruticosum* from other places at Agra; of *Luffa graveolens* from the Mala forest in Pilibhit district; of *Trichosanthes cucumerina* from Katiar (Bihar); of *Cyclanthera pedata*, *Edgaria darjeelingensis*, *Herpetospermum caudigerum*, and *Sechium edule* from Darjeeling; and that of *Gymnopetalum cochinchinense* from Teesta (about 40 miles from Darjeeling). *Dicaelospermum ritchiei* was collected by Messers S. N. Chaturvedi and O. P. Madhok from Pachmari. The fixed material of *Echinocystis wrightii* was kindly sent to me by Dr. E. J. H. Corner from Cambridge and that of *Passiflora foetida* by Mr. S. S. Ramam from Andhra. The prepared slides of *Cyclanthera explodens* were passed on to me by Prof. Bahadur Singh.

Usual methods of dehydration, embedding, section cutting, and staining were followed. Chalazal endosperm haustorium was studied from microdissections. The study of seed coat was made through macerations, teasing, free hand sections along with the microtome sections.

The ovules are anatropous, bitegmic and crassinucellate in all the plants studied. They are pendulous in *Cyclanthera*, *Dicaelospermum*, *Edgaria*, *Herpetospermum*, and *Sechium*; while in the remaining plants of Cucurbitaceae, they are horizontal and lie at right angles to the long axis of the ovary. In Caricaceae, Passifloraceae, and Violaceae the micropyle is formed by both the integuments while in Cucurbitaceae the inner integument alone takes part in its formation. The nucellar beak reaches various heights in the micropyle and the nucellar apex in *Dicaelospermum*, *Edgaria*, *Herpetospermum*, *Melothria*, and *Sechium* remains almost in a line with the apex of the integuments.

The inner integument consists of 2-4 layers of cells in Cucurbitaceae except in *Sechium edule* which has usually 4-6 or more layers of cells. The outer integument is massive but its thickness varies in different plants. In *Carica papaya* both the integuments consist of 5-6 layers of cells, while in *Passiflora foetida*, *Viola tricolor*, and *Ionidium suffruticosum* they are formed only of three layers each.

In *Carica*, *Passiflora*, *Ionidium*, and *Viola* a single vascular bundle forms the ovule supply which terminates at the chalaza. In Cucurbitaceae on the other hand the ovular supply consists of a bundle going up to the tip of the outer integument. Only in *Cyclanthera*, *Momordica*, and *Trichosanthes* it ramifies in the outer integument. In *Sechium*, however, there are three or four vascular bundles which fuse with each other, while travelling the raphe, to form a single strand. Branches are also given out from these ovular bundles before as well as after fusion. The massive vascular supply to the single ovule of *Sechium* is shown to be a derived condition due to reduction in the number of ovules.

The pollen tube is porogamous with no appreciable difference in its width at the time of entry. Later on, in ovules of *Carica, Cyclanthera, Dicaelospermum, Edgaria, Herpetospermum,* and *Melothria* it is observed to dilate in the nucellar beak. Similar dilation of the pollen tube of the Cucurbitaceae has been reported earlier but the authors (Longo, 1904; & Kirkwood, 1906) considered that this takes place before fertilisation and that the dilation is associated with the presence of starch grains in the nucellar beak or the integuments. The present observations clearly reveal that the pollen tube dilates only after fertilisation without showing any positive correlation with the presence of starch grains.

The pollen tubes are persistent in the members of Cucurbitaceae, Caricaceae, and Passifloraceae, while in *Ionidium* and *Viola* only rarely for a short time they may persist. In *Passiflora foetida* such pollen tubes may occasionally form convolutions inside the embryo sac. No physiological function could, however, be attributed to these.

The endosperm development is free nuclear. In Cucurbitaceae, during later stages, the free nuclear endosperm differentiates into a vesicular upper part, the endosperm proper, and a narrow, tubular chalazal haustorium. Later on, the vesicular part becomes cellular while the chalazal caecum remains either coenocytic or becomes cellular depending upon the size attained by it. In *Dicaelospermum, Edgaria,* and *Herpetospermum* even the lower part of the endosperm proper remains free nuclear. Chopra and Agrawal (1958) think that the chalazal endosperm haustorium which may grow up to 1500μ may remain free nuclear or it may become cellular, while haustoria more than 1500μ long always remain coenocytic. The present investigation supports this on the bais of the data collected on a large number of plants.

The haustorium remains active up to the heart-shaped stage of the embryo, after which it shrinks and finally disappears. With the decline of the haustorial activity the peripheral cells of the chalazal part of the endosperm proper bulge out. In *Luffa acutangula* (hermaphrodite var.) and *L. graveolens* these cells also divide and form short cellular mounds representing secondary haustoria. In the micropylar region of the endosperm the peripheral cells remain small while the central ones, lying in the vicinity of the embryo, enlarge considerably.

The free nuclear endosperm develops nucleated cytoplasmic nodules in *Carica papaya* and non-nucleated in *Passiflora foetida, Ctenolepis cerasiformis, Cucumis melo* var. *pubescens, Cyclanthera explodens, Dicaelospermum ritchiei, Echinocystis wrightii, Edgaria darjeelingensis, Herpetospermum caudigerum, Luffa acutangula* (hermaphrodite var.), *Momordica charantia,* and *Sechium edule.* These nodules grow from the peripheral cytoplasm of the free nuclear endosperm into the central vacuole in the form of bulges of definite shape. They are generally better developed in the plants collected from higher altitudes or cold countries, while only weaker ones are observed in plants from warmer parts. Later on, these nodules grow, fuse with each other and ultimately amalgamate with the general cytoplasm of the endosperm. The nodule formation usually progresses from micropylar to the chalazal end except *Passiflora foetida* in which they appear simultaneously in the micropylar and the chalazal parts of the endosperm. The nodule formation is an active method for the filling up of the central vacuole of the endosperm.

Behaviour of the endosperm nuclei, during the advanced stages of seed development, is studied in *Cucumis sativus*, *Cucurbita pepo*, *Cyclanthera pedata*, *Herpetospermum caudigerum*, *Sechium edule*, and *Trichosanthes cucumerina*, from the fixed materials only. These nuclei show increase in size and lobing. In the haustorium of *Cyclanthera* they become vermiform. As the nuclei increase in size the nucleoli acquire different shapes, become amoeboid and also show fragmentation. In *Cucumis* fusion of nuclei is also observed. These are probably the steps leading to the disintegration and final resorption of the endosperm nuclei by the growing embryo.

The endosperm in Cucurbitaceae is mostly utilised by the growing embryo and in a mature seed only one or two peripheral layers are left. In *Carica papaya*, *Passiflora foetida*, *Ionidium suffruticosum* and *Viola tricolor* it forms the main storage tissue of the seed.

Embryo development of *Citrullus colocynthis*, *Dicaelopsermum ritchiei*, *Melothria maderaspatana*, and *Passiflora foetida* confirms Myosurus variation of Onagrad type. The embryo development in *Carica papaya* could not be assigned to any particular type because of irregular divisions in the earlier stages of development.

In *Carica papaya*, *Passiflora foetida*, *Ionidium suffruticosum*, and *Viola tricolor* both the integuments take part in the formation of the seed coat. The characteristic mechanical layer in all these plants develops from the outer epidermis of the inner integument. In *Carica*, *Ionidium*, and *Viola* calcium oxalate crystals are deposited in the cells of the inner epidermis of the outer integument. *Carica papaya* shows that the outer epidermis of the outer integument, after division, forms the sarcotesta in a mature seed, while its peripheral sub-epidermal layers undergo divisions which are vigorous in the positions destined to form ridges and less so in those of furrows. This tissue forms the bulk of the black endotesta of the seed coat. In *Passiflora foetida* the cells of the mechanical layer are radially and unequally elongated forming ruminations towards the inner side of the seed coat.

In Cucurbitaceae the seed coat is formed of the outer integument only; the inner integument degenerates, sooner or later, and is finally completely lost in a mature seed. The mature seed coat of Cucurbitaceae is differentiated into six parts (1) epidermis, (2) sub-epidermal tissue, (3) main sclerenchyma layer (all derivatives of the outer epidermis), (4) aerenchyma-derived from the integumentary hypodermis, (5) chlorenchyma-formed of the sub-hypodermal layers, and (6) inner epidermis of the outer integument forming the innermost layer of the seed coat.

The seed epidermis shows rod-like, reticulate or spiral thickenings on their radial walls. These thickenings may also extend to the sub-epidermal tissue, which is either wholly or partly lignified. The cells of the innermost sub-epidermal layer are radially elongated in *Luffa* species, simulating the cells of the sclerenchyma layer.

The sclerenchyma forms the most characteristic layer of the cucurbitaceous seed coat and its cells may be either tangentially elongated, broad and polygonal, or radially elongated. They are lignified and greatly thickened. The tangentially elongated or broad and obliquely placed cells show a less advanced condition, while radial elongation a more advanced feature in Cucurbitaceae.

The aerenchyma, chlorenchyma, and the inner epidermis of outer integument after separation from the protective layer form the tegmen. Seminal root primordia occur in *Cyclanthera* and *Sechium* which also show vivipary. In the former the cotyledons, as well as the seminal leaves are observed to develop glandular hairs on the surface facing the apical primordia of epicotyl.

On the basis of the development and structure of ovule, endosperm and seed coat the family Cucurbitaceae is found to show no significant resemblances with Caricaceae, Passifloraceae, Violaceae, and other related families with which it is customarily associated. It is interesting to find that there are some resemblances with Leguminosae which goes to support the origin of Cucurbitaceae from the Calycifloral plexus as pointed out by Wernham (1911); and that the family deserves the status of an order forming an advanced and terminal taxon of polypetalae.

The division of the family into five tribes *i.e.*, Fevillae, Melothrieae, Cucurbiteae, Sicyoideae, and Cyclantherae, which does not find any support from the embryological studies, is, however, supported from the seed coat studies. The structure and orientation of the cells of the main sclerenchyma layer is to some extent constant in the plants of each tribe. But the breaking of the tribes into sub-tribes is not at all supported even on the basis of seed structure. The sub-tribe Dicaelopserminae which is formed on the basis of erect or orthotropous ovules is artificial as in *Dicaelospermum* the ovules are anatropous like other members of the tribe. It is also suggested to shift *Edgaria*, which shows close resemblances with *Herpetospermum* in the structure of the endosperm and seed coat, from Melothrieae to Cucurbiteae.

I owe a debt of gratitude to Prof. Bahadur Singh for suggesting me the problem and giving me valuable guidance throughout the course of this study. My thanks are also due to Dr. Satya Pal Singh and Dr. R. L. Paliwal for critically going through the manuscript.

LITERATURE CITED

Bentham, G. & Hooker, J.D. 1862-1883. "Genera Plantarum". London.

Bessey, C. E. 1915. The phylogenetic taxonomy of flowering plants. *Ann. Mo. Bot. Gard.* **2**: 109-164.

Chakravorti, A.K. 1947. The development of female gametophyte and seed of *Coccinia indica* W. & A. *J. Indian Bot. Soc.* **26** : 95-104.

Chopra, R. N. 1953. The endosperm in some Cucurbitaceae. *Curr. Sci.* **22**: 383-384.

Chopra, R. N. 1954. Occurrence of endosperm haustoria in some Cucurbitaceae. *Nature* **173** : 352-353.

Chopra, R. N. 1955. Some observations on endosperm development in the Cucurbitaceae. Phytomorphology **5** : 219-230.

Chopra, R.N. & Agrawal, Saroj 1958. Some further observations on the endosperm haustoria in the Cucurbitaceae. Phytomorphology **8** : 194-201.

*De Candolle, A.P. 1824-1873."Prodromus systematics naturalis regni vegetablis". **17** Paris.

Engler, A. & Gilg, E. 1924. "Syllabus der Pflanzenfamilien". Berlin.

Engler, A. & Prantl, K. 1889."Die naturalichen Pflancenfamilien". Berlin.

Gundersen, A. 1950. "Families of Dicotyledons". Waltham, Mass., U. S. A.

Hutchinson, J. 1926-1959 "The families of flowering plants". Vol. **1** Dicotyledons. London.

Janchen, E. 1932. Enturf eines Staümbaumes der Blutenpflanzen nach Richard Wettstein. *Ost. bot. Z.* **81**: 161.

Johri, B.M. and Roy Chowdhury, Chhaya 1957. A contribution to the embryology of *Citrullus colocynthis* Schrad. and *Melothria maderaspatana* Cogn. New Phytol. **56**: 51-60.

Kirkwood, J. E. 1905. The comparative embryology of Cucurbitaceae. *N. Y. Bot. Gard.* **3**: 313-403.

Kirkwood, J. E. 1906. The pollen tube in some of the Cucurbitaceae. *Bull. Torrey Bot. Club* **33**: 327-341.

Kratzer, J. 1918. Die Venwandtschaftlichen Benziehungen der Cucurbitaceen auf Grund ihrer Samenentwicklung mit spezieller Berüchsichtigung der Caricaceen, Passifloraceen, Aristolochiaceen ond Loasaceen. Flora **10**: 275-343.

Lawrence, H. M. 1951. "Taxonomy of vascular plants". New York.

Longo, B. 1904. Richerche sulla Cucurbitaceae e il significato del percorso intercellulare (endotropico) del tubetto pollinico. R. Acad. Del. Lincei. **4**: 523-549.

Pool, J. R. 1941. "Flowers and Flowering plants". London.

Rendle, A. B. 1925. "The classification of the flowering plants". **11** *Dicotyledons. Cambridge.*

Singh, B. 1952. Studies on the structure and development of seeds of Cucurbitaceae. I. Seeds of *Echinocystis wrightii* Cogn. *Phytomorphology* **2**: 201-209.

Singh, B. 1953. Studies on the structure and development of seeds of Cucurbitaceae. *Phytomorphology* **3**: 224-239.

Singh, D. 1955a. Embryological studies in *Cucumis melo* var. *pubescens* Willd. *J. Indian Bot. Soc.* **34**: 72-78.

Singh, D. 1955b. Cytoplasmic nodules in the endosperm of some Cucurbitaceae. *Nature* **176**: 607-608.

Singh, D. 1956. A contribution to the embryolgy of some members of the family Cucurbitaceae. *Proc. Indian Sci. Cong.* **43**: 222-223.

Singh, D. 1957. Endosperm and its chalazal haustorium in Cucurbitaceae. *Agra. Univ. J. Res.* **6**: 75-89.

Souèges, R. 1939. Embryogénie des. Cucurbitacées. Développement de l' embryon chez le *Bryonia dioica* Jacq. C. R. Acad. Sci. Paris **208**: 227-228.

Tillman, O. J. 1906. The embryo sac and embryo of *Cucumis sativus*. *Ohio Nat.* **6**: 423-430.

Vuillemin, P. 1923. Recherches sur les Cucurbitaceae type-anomalies-affinities. *Ann. de Sci. Nat. Bot.* **5**: 5-19.

Weiling, F.&Schagen,R.1955. Über die präparation and Gestalt des Endosperm-haustoriums bei denn grossamigen Kurbisarten. *Ber. dtsch. bot. Ges.* **68**: 1-10.

* Wernham, H. F. 1911. Floral evolution. *New Phytol.* **10**: 78-83, 109-120, 145-159, 217-226, 293-307.

Wettstein, R. 1911 & 1935. "Handbuch der Systematischen Botanik." Leipzig and Wein.

THE ANATOMY AND DEVELOPMENT OF LAMELLIDENS MARGINALIS (LAMARCK)*

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SUMMARY

The author has studied the Bionomics and Distribution, Anatomy and Development of the common Indian Fresh-water mussel, *Lamellidens marginalis* (Lamarck) in detail. The more important new features discovered by him are as follows:

THE SHELL

(1) Contrary to previous belief, the beak in the young Lamellidens is covered with the periostracum, which, however, gets worn off later.

(2) The prismatic layer consists of a single layer of almost rectangular blocks and is narrow, while the nacreous layer is broad and vertically laminated.

(3) Unlike Anodonta, each shell-valve bears at the hinge-line a set of teeth fitting into the sockets of the other shell valve.

THE MANTLE LOBE

(4) The two pallial lobes are fused together dorsally along the mid-dorsal line of the viscero-pedal mass, and produced into a narrow, laterally compressed ribbon-like band whose configuration and histological structure vary in different regions.

(5) The ventral margin of the mantle lobe bears three small pallial folds enclosing a deep outer periostracal groove and a shallow inner groove.

(6) The internal surface of the mantle lobe forming the wall of the exhalent and the inhalent siphons, is bounded by a layer of ciliated columnar epithelium.

(7) In the pre-siphonal zone the mantle lobe has an outer and an inner layer of muscles. The former, lying a little below the dorsal extremity of the mantle lobe, crosses over obliquely towards the inner surface and then extends upwards.

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* This is an abstract of the thesis submitted for the Ph. D. degree of the Agra University in the year 1959-60.

(8) In the siphonal zone the mantle lobe has three muscle layers. In transverse sections of the mantle lobe through this region the outer and the inner muscle layers appear as discontinuous bundles, whereas the median muscle layer is formed of continuous fibers.

(9) The two mantle lobes, in addition to the pallial cavity, enclose between them a minute anterior pallial recess on the dorsal suface of the anterior adductor muscle, and a small posterior pallial recess dorsal to the posterior adductor muscle.

THE MUSCLES

(10) Some of the fibres of the right anterior retractor muscle extend as a thin septum into the anterior adductor muscle, thereby dividing it into two unequal portions.

(11) Both the right and the left anterior retractor muscles bifurcate within the pedal mass so as to form two bands—a vertical band running straight downwards, and an oblique band crossing obliquely to the other side of the pedal mass.

(12) The muscle bands of the visceral region consist of numerous small bundles of plain muscle fibres, running in a subhorizontal or oblique direction among the diverticula of the digestive gland and the alveoli of the gonad.

THE GILLS

(13) In *Anodonta cygnea* owing to the detachment of the inner lamellae of the inner demibranchs from the viscero-pedal mass, the inner suprabranchial canal on each side communicates by a slit-like aperture with the pallial cavity. In *Lamellidens marginalis*, however, there is no such communication.

(14) In Anodonta the subfilamentar outgrowths are cylindrical. In *Lamellidens*, however, a number of subfilamentar out-growths are oval while the others are cylindrical.

(15) The external demibranch is comparatively short in length and height, while the internal demibranch is deeper and extends beyond the overlapping external one at its anterior and ventral borders.

(16) At its anterior region the internal demibranch is differentiated into two regions—an upper one with an even surface, and a lower one with a corrugated appearance and it encloses numerous blood corpuscles in the lacunar interspace inside it.

(17) Anteriorly the outer demibranch shows three regions : a broad proximal region, a neck-like middle region and a ventral corrugated region.

(18) The outer and the inner lamellae of the demibranch are here and

there joined by inter-lamellar junctions containing plain muscle fibres, and a loose connective tissue with blood corpuscles.

(19) There are certain transverse shelf-like projections developed on the inner wall of the lamella and projecting freely into the interlamellar cavity.

THE DIGESTIVE SYSTEM

(20) The upper lip which is more prominent than the lower lip projects forwards in front of the mouth so that the latter seems to face obliquely downwards.

(21) The external surface of the outer and the inner labial palps is formed of cuboid epithelium, while the opposing surfaces of the palps enclose a palpar gutter and are characterised by numerous niches lined by ciliated columnar cells.

(22) The stomach is enveloped all round by the diverticula of the digestive gland which sends three ducts into it, one dorsally and two laterally.

(23) The gastric shield is a gelatinous structure lying over the postero-dorsal wall of the stomach. Transverse sections of the stomach show that it consists of two limbs of almost equal length joined by a thick median piece projecting into the lumen of the stomach.

(24) On account of a prominent inpushing in the ventral wall of the descending portion, the intestinal lumen is divided into two intercommunicating spaces : a large spheroidal style-sac enclosing the crystalline style and an elongated and depressed vestibule.

(25) The ascending part of the intestine has a fairly large typhlosole; opposite to the typhlosolar side the wall of the intestine is folded up to form a few small cup-like depressions.

(26) The typhlosole is present all along the ventral wall of the rectum.

(27) The anal papilla is the posterior extension of the ventral typhlosole of the rectum.

THE BLOOD VASCULAR SYSTEM

(28) The peri-aortic anterior crescentic region of the pericardium laterally sends two narrow tubular structures on either side of the rectum to open into the kidneys through the reno-pericardial apertures.

(29) Posteriorly, the pericardium is much compressed dorsoventrally and assumes a U-shape.

(30) At the auriculo-ventricular junction a pair of valves are present projecting into the ventricle.

(31) The anterior aorta has an oblique disposition on the right side of the visceral portion.

(32) The disposition of the visceral artery in *Lamellidens marginalis*, however, is considerably different from that in *Anodonta cellensis*.

(33) After passing obliquely forwards and downwards along the junction of the visceral mass with the anterior extension of the muscular foot, the pedal artery curves backwards and runs posteriorly along the junction of the visceral and pedal portions. From the pedal artery arise numerous lateral branches, which branch and re-branch further, thereby forming a network of blood vessels inside the foot.

(34) The anterior and posterior pallial arteries unlike those in Anodonta, do not unite with each other to form a circum-pallial artery.

(35) There are no veins as in *Anodonta*, but numerous irregular-shaped, inter-connected sinuses are present.

THE NERVOUS SYSTEM

(36) The cerebral, pedal and the visceral ganglia have essentially the same histological structure. In them two distinct concentric zones are present, *viz.*, an outer cortex consisting of numerous unipolar nerve cells and an inner medulla with many extremely fine nerve fibres.

(37) In *Anodonta cellensis* there are five pallial nerves arising from each cerebro-pleural ganglion, but *Lamellidens marginalis* has only two such nerves.

(38) In *Lamellidens marginalis* although the origin and disposition of Nervus pedalis IV, is similar to that in *Anodonta cellensis*, it reaches only half the length of the foot.

(39) In its histological structure each branchial nerve resembles a typical ganglion.

(40) The posterior adductor muscle in *Anodonta cellensis* is innervated by three pairs of nerves. In *Lamellidens marginalis*, however, the posterior adductor muscle is innervated by only one pair of nerves.

(41) On the dorsal side of the viscero-pedal mass immediately anterior to the posterior adductor muscle the right and the left cerebro-visceral connectives lie abutting against each other, enclosed in a common connective tissue tube.

THE RECEPTOR ORGANS

(42) In sexually immature *Lamellidens* the statocysts are seen in the immediate vicinity of the pedal ganglia, but in the adults they are displaced far into the visceral region by the alveoli of the gonad.

(43) The statocyst is innervated by the statocyst nerve which arises as a branch of the cerebro-pedal connective.

(44) The osphradium is situated in close proximity to the visceral ganglia.

(45) The epithelium of the foot is corrugated to form numerous villi-like folds constituting the pedal receptor organs which are bounded by columnar cells with oval nuclei and bearing at their free ends tufts of projecting cilia.

(46) The tentacle-like projections of the inhalent siphon are very sensitive to light.

The Excretory System

(47) The Keber's organ which is described in *Anodonta* is absent in *Lamellidens.*

(48) The structure of the kidney is considerably different from that in *Anodonta.*

The Reproductive System and Development

(49) Sexual dimorphism is evinced in size, shell-valves, ctenidia and gonads.

(50) The ciliated gonoduct on each side of the visceral region opens into the interlamellar cavity of the inner demibranch slightly ventral to the external aperture of the renal duct.

(51) In *Anodonta* the ova in various stages of development remain separate from each other inside the water tubes of the outer demibranchs. In *Lamellidens marginalis,* however, the developing ova are agglutinated together to form plate-like structures that vary in size and shape.

(52) The glochidium of *Anodonta* has a shall composed of a pair of triangular valves terminating in stout hooks. But in *Lamellidens* the shell-valves of this larva are almost semi-circular with an even border devoid of hooks.

STUDIES ON THE PECTORAL GIRDLE AND ITS MUSCULATURE (WITH INNERVATION) OF RANA TIGRINA DAUD. AND BUFO ANDERSONII BOULENG.*

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PART I

The Pectoral Musculature (with Innervation) of Rana tigrina Daud. and Bufo andersonii Bouleng.

The author has studied the pectoral girdle and the associated musculature and innervation minutely in a representative of the Firmisternia (*Rana tigrina* Daud.) and that of the Arcifera (*Bufo andersonii*/Bouleng.). The more important features discovered by him are as follows:-

1. The posterior border of the suprascapula is directed obliquely backwards in *R. tigrina,* and in an almost transverse direction in *B. andersonii.*

2. The xiphisternum consists of a bony piece and a cartilaginous plate in *R. tigrina,* and of a single undivided cartilage in *B. andersonii.* There is no median notch in the pars cartilaginea in *Rana tigrina.*

3. The coracoids overlap each other both in *R. tigrina* and *B. andersonii,* but in the former they are calcified and immovably united with each other, while in the latter they have cartilaginous epicoracoids attached to their mesial border and can slide over each other.

4. Both in *R. tigrina* and *B. andersonii,* the *levator scapulae inferior* and the *levator scapulae superior* consist of two distinct portions.

5. The *rhomboideus anterior* is inserted on the ventral surface of the suprascapula in *R. tigrina,* and on the .dorsal surface in *B. andersonii.*

6. In *R. tigrina* the *rhomboideus posterior* lies in close proximity to the *serratus superior* and takes its origin from the tendinous sheath joining the processus spinosus III with the processus spinosus IV, but in *Bufo andersonii* it is not in contact with the *serratus superior* and originates from the tendinous sheath connecting the processus spinosus II with the processus spinosus III.

7. Both in *R. tigrina* and *B. andersonii* there are, instead of the *serratus medius* of *R. esculenta,* two muscles—the *serratus medius externus* and the *serratus medius internus.*

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* This is an abstract of the thesis submitted for the Ph. D. degree of the Agra University in 1959.

8. The *cucullaris* mainly arises from the synchrondrosis prootico occipitalis in *R. tigrina,* and from the cartilaginous crista parotica in *B. andersonii.*

9. Instead of the serratus inferior, there are in *R. tigrina* and *B. andersonii* two muscles—the *serratus inferio-anterior* and the *serratus inferio-posterior,* which have been described in detail.

10. The *omohyoideus* of *R. tigrina* differs in its site of origin, size and direction from that of *B. andersonii.*

11. The *sternohyoideus* in both species consists of a portio anterior (subdivided into two parts) and a portio posterior, the two differing in their insertions.

12. The *cutaneus pectoris* is absent in *B. andersonii.*

13. The *rectus abdominis portio medialis* is inserted on the pars cartilaginea of the xiphisternum in *R. tigrina,* but on the posterior end of the junction between the coracoid and the epicoracoid in *B. andersonii.*

14. The *interscapularis* arises from the whole breadth of the suprascapula in *R. tigrina,* but only from the anterior four-fifths of the breadth of the suprascapula in *B. andersonii.*

15. The *coraco-radialis* of *R. tigrina* differs from that of *B. andersonii* in its origin and relative position to other muscles.

16. The *latissimus dorsi* of *B. andersonii* is much less developed than that of *R. tigrina* and differs from the latter in its origin.

17. The *dorsalis scapulae* consists of two parts in both species.

18. The *deltoideus* both in *R. tigrina* and *B. andersonii* consists of a pars scapularis, a pars clavicularis and a pars cleido-humeralis longus, which have been described in detail.

19. The differences between the *pectoralis* of *R. tigrina* and that of *B. andersonii* have been pointed out.

20. The *scapulo-humeralis profundus anterior* and the *scapulo-humeralis profundus posterior,* which were not found in *R. esculenta* by Gaupp (1896), have been observed in *R. tigrina,* as well as in *B. andersonii.*

21. The *pars superficialis* of the *coraco-brachialis brevis* has a slightly different site of origin in *R. tigrina* from that in *B. andersonii.*

22. The *pars profunda* of the *coraco-brachialis brevis* is differentiated into two portions in *R. tigrina* and three in *B. andersonii.*

23. The *coraco-brachialis longus* takes its origin in *R. tigrina* from the junc-

tion of the coracoid with the pars ossea of the xiphisternum, and in *Bufo andersonii* from the median end of the coracoid.

24. In *R. tigrina* the *ramus coraco-brachialis* of the *pectoralis communis* supplies the portio epicoracoidea, but in *B. andersonii* it supplies the portio anterior of the coraco-brachialis brevis pars profunda.

25. The branch of the *ramus pectoralis proprius* that supplies the cutaneus pectoris in *R. tigrina* is absent in *B. andersonii.*

PART II

The Development of the Pectoral Girdle in Rana tigrina Daud. and Bufo andersonii Bouleng.

The development of the pectoral girdle has been studied in *Rana tigrina* Daud. and *Bufo andersonii* Bouleng. The following important features have been observed:-

1. The limb-bud makes its appearance after the formation of the operculum. The tadpoles from this stage onwards can be placed in twelve successive stages—six premetamorphic and six metamorphic. They have been numbered successively from 26 to 37 in view of the fact that the preceding embryonic stages have been described by Shumway (1940) as stages I-XXV.

2. In both the types the development of the pectoral girdle starts from a mass of mesenchyme which hangs, as the anterior limb-bud, into the opercular chamber.

3. Both in *Rana tigrina* and *Bufo andersonii* the skeleton of the limb appears first and that of the pectoral girdle later.

4. From the proximal part of the limb-bud the mesenchyme extends upwards and downwards along the inner wall of the opercular chamber. Separate condensations in this extension start forming the rudiments of the scapula, procoracoid and the coracoid.

5. In both the species a coraco-scapular plate is not formed.

6. After the caput humeri are well formed the proximal ends of the rudiments of the scapula, procoracoid and the coracoid meet together to form the glenoid cavity. Such a mode of formation of the glenoid cavity is different from that described by other workers, and is perhaps correlated with the absence of a coraco-scapular plate.

7. The mode of emergence of the fore-limbs from the opercular chamber has been described in detail.

8. Generally the left anterior limb is the first to emerge out of the opercular chamber,

9. During the emergence of the anterior limb the glenoid cavity shifts downwards.

10. The distal margin of the coracoid of the left side is situated ventral to that of the right, but in some of the specimens the reverse is the case. In the latter cases the right anterior limb emerged first.

11. The *thorakale* (Fuchs 1922) is not formed.

12. The procoracoid becomes ossified, like the coracoid.

13. The clavicle is absent.

14. Goodrich's (1930) use of the term "fenestra" in connection with the "coracoid fontanelle" is inappropriate, as the space bounded in front by the procoracoid and behind by the coracoid is covered by a membrane.

15. A true sternum is present, comparable to that of the Amniota.

16. The sternum in *Rana tigrina* consists of an episternum and a xiphisternum, while in *Bufo andersonii* it consists of a xiphisternum only. The difference in development in this connection has been studied.

17. In *Bufo andersonii* the procoracoids almost approach the glottis, while in *Rana tigrina* they are at a distance from it. In correlation with this, in the former the episternum is absent while in the latter the space between the glottis and the procoracoids is occupied by the episternum.

18. Each component of the sternum in *Rana tigrina* is formed by the fusion of a pair of longitudinal bars which appear in the mesenchymatous plate.

19. The sternum proper (xiphisternum) in *Bufo andersonii* appears almost in the same way as that in *Rana tigrina.*

20. The mesenchymatous plate, in which the components of the sternum are formed, develops longitudinally along the ventral septum in this region.

21. In *Rana tigrina* the mesenchymatous plate extends anterior and posterior to the distal ends of the procoracoid and the coracoid and also in between them. In *Bufo andersonii* the plate extends only backwards from the distal posterior end of the cartilago epicoracoidea; and for some time it remains divided into two longitudinal plates due to the intestine in this region. Later on as the intestine recedes, the longitudinal plates unite.

22. The pars cartilaginea of the episternum and the xiphisternum are formed in the distal end of the proximal components (pars ossea) of the sternum.

23. In *Rana tigrina* the middle part of the mesenchymatous plate joins the overlapping coracoids, thus forming the cartilago epicoracoidea. In *Bufo*

andersonii, on the other hand, the cartilago epicoracoidea are formed independent of the mesenchymatous plate.

24. In *Bufo andersonii* the union of the distal ends of the procoracoids becomes firm before the intestine recedes.

25. While in *Rana tigrina* the anterior distal margin of the coracoid is in direct continuation with the distal end of the procoracoid, in *Bufo andersonii* the two are connected by a cartilago epicoracoidea.

THE SERUM ELECTROLYTE STUDIES IN ACUTE ABDOMINAL EMERGENCIES*

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Acute abdomen frequently results in disturbances of water, electrolyte and protein metabolism. Abnormalities in water and electrolyte balance occur not only because of interference of normal intake of food, water and salt, but are also due to uncontrollable, large losses of water and electrolytes caused by vomiting or the use of gastric suction in the management of these cases.

For more than three decades the alteration which takes place in the chemistry of blood during intestinal obstruction have interested many workers, who have sought to explain the course and termination of unrelieved obstruction on the basis of the changes observed in the chemical constituents of blood.

This work is mainly centered round the cases of Intestinal Obstruction, Stangulated Hernia, Acute Appendicitis and Generalised Peritonitis, these were studied right from the time of admission and followed up till their recovery or death. Cases were encountered on one hand, those who came soon after the onset of the disease and in whom the dehydration or loss by vomiting was minimal or none at all and on the other hand, delayed cases, in whom dehydration, and loss by vomiting was marked. Some cases were operated and others treated conservatively.

The blood for estimation of electrolytes was taken at the time of admission, before administration of saline, and at varying intervals during their stay in the hospital. The serum was seperated and estimations of sodium and potassium was done by flame photometry and of chloride by chemical method. The clinical progress of the cases from day to day was also recorded.

OBSERVATIONS

Part I. Normal Serum Electrolyte Values.

Sodium	Average-133.49	mEq/L	Range	120-146.5	mEq/L
Potassium	,, 5.13	mEq/L	,,	3.84-6.00	mEq/L
Chloride	,, 100.22	mEq/L	,,	90.51-104.21	mEq/L

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Part II. Cases, Serum Electrolyte Levels.

		At the time of Admission	third day	Fifth day.
1. Sodium:				
	Low	9	2	Nil
	Normal	16	15	12
	High	5	10	11
2. Potassium:				
	Low	7	12	5
	Normal	21	15	16
	High	2	...	2
3. Chloride:				
	Low	6	1	2
	Normal	20	23	17
	High	4	3	4

Clinically Hypokalemia was observed in—

	Total Cases	Hypokalemia observed No. of Cases	Days after onset of disease.	Blood Serum Level	Result	Remark
Ac. Int. Obst.	11	6	2	4.16-3.16	Died	Severe vomiting
			7	6.1	,,	Dehydration
			7	3.6-2.5	,,	
			9	2.5-1.92	,,	
			10	6.1-1.92	,,	
			15	3.7	,,	
Strang. H.	5	...	...	...	Cured	
Gen. Perit.	5	3	4	2.88	Died	Marked vomiting
			6	2.5	,,	
			17	1.92	,,	
Ac. Append.	9	4	6	2.8	Cured	Oral fluid started.
			8	1.92	,,	
			10	2.55	,,	
			15	2.55	Died.	

It was observed that longer the duration of illness, more the vomiting or gastric aspiration, the lower was the level of serum potassium. Hypokalemia was observed in 13 cases out of which 10 died. The remaining 3 cases were those in which oral therapy was started on admission of the cases.

Clinically hypokalemia was observed mostly with serum potassium level of less than 4 mEq/L. In 2 cases hypokalemia was observed with serum potassium level of 6.00 mEq/L. This was due to dehydration. One of the cases expired soon after admission and the other cases showed the serum potassium level of 1.92 mEq/L on the second day after the parenteral fluid was given.

DISCUSSION

The report of the cases show that during acute intestinal obstruction both mechanical and paralytic, the concentration of serum potassium tends to fall, often to a considerable degree. The concentration of sodium and chloride also tends to fall but their reduction is less severe than that of potassium. Because of the wide range of the normal values, the decision of whether or not the concentration of serum potassium in individual case is altered should rest on changes found on repeated estimations rather than on single observation. The correlation of history and the physical sign is the first step taken in the formulation of a presumptive clinical understanding of the type of fluid disequilibrium present.

Scudder, Zemer and Whipple in the analysis of blood serum of 20 cases of intestinal obstruction before the start of saline, found elevated plasma potassium in 7 cases and decreased in 5. Falconer, Ostenberg and Bargen found the serum potassium level tends to fall often to a considerable degree in cases of acute intestinal obstruction. Bellet, Nadler, Gazes and Lanning also observed low serum potassium level in cases of acute intestinal obstruction. They also observed that in practically all cases the serum potassium tends to fall to a still-lower level following parenteral therapy which did not include potassium.

Serum electrolyte concentration is governed by a large number of factors such as, starvation, dehydration, administration of fluids, vomiting and operation.

In starvation there is a considerable loss of nitrogen from the cell, and this is directly related to the loss of potassium. Benedict showed that from each gram of nitrogen 2.87 mg. of potassium is also lost.

PARENTERAL ADMINISTRATION OF GLUCOSE AND SALINE

Tends to diminish the serum potassium causing the potassium to enter the muscle and liver in association with glycogen formation, particularly when the cellular potassium is low. In addition glucose tends to produce a transient depletion of salt and helps to eliminate potassium by diuresis. The glucose also has a sparing effect on the protein loss which occurs when patients is not taking food.

Falconer, Ostenberg and Bargen deduced from their experimental study in healthy male adult, that although the administration of large of solutions of sodium chloride in blood, will cause a slight decrease in the concentration of potassium in the blood, continued and repeated administration will not depress it further.

THE EFFECT OF OPERATION

The most important feature of this response may be summarised as follows: (a) for 24-48 hours there is an impaired ability to excrete water (a) diminished urine flow of raised specific gravity and electrolyte concentration, (b) for 4-5 days after a major operation there is an impaired ability to excrete salt.

THE EFFECT OF LOSSES FROM ALIMENTARY TRACT (VOMITING OR GASTRIC ASPIRATION)

As a result of loss from the body of the intestinal fluid and also because of the interference with the normal intake caused by obstruction they will develop a combined deficit of water and salt. Initially water depletion causes hypertonicity in the extracellular space, leading to a shift of water out of the intracellular space and so resulting in intracellular dehydration. By contrast salt depletion causes initially an extracellular hypotonicity, leading to an excretion of water by the kidneys in an effort to restore extracellular tonicity and so resulting in extracellular dehydration. This dehydration does not result in equal contraction of the two portions of the extracellular space namely the interstitial and plasma spaces, as at first the osmotic force of the plasma proteins maintains the plasma volume at the expense of the interstitial space, but as the condition progresses this mechanism breaks down, resulting in a contracting plasma volume and finially peripheral circulatory failure.

These difference in the type of dehydration caused are reflected in the different chemical and biochemical effects of the two losses. The prominent clinical feature of water depletion is increasing thirst, sparse urine with raised specific gravity and high salt content. As the brunt of loss falls on the intracellular space there are no significant changes in the blood until late in the condition, when there will be steady rise in plasma electrolyte concentration. In salt depletion thirst is noticeably absent, but as the condition progresses the patient becomes lethargic and nauseated with postural giddiness and eventually extreme weakness. In the early stages the important physical finding are dryness of the skin and mouth with diminishing skin elasticity, and later on as the blood volume begins to fall there will be postural hypotension progressing to complete picture of peripheral circulatory failure. It cannot be too strongly emphasised that a large deficit of sodium and/or chloride can readily exist with normal levels of these ions in serum.

Two other effects of the loss of intestinal fluids requires note. As already mentioned, in some of the intestinal secretions the concentration of sodium and chloride is not equal so that losses of these fluids can readily lead to diproportionate deficit of either sodium or chloride, resulting in an acid base disturbance. In most cases of intestinal obstruction the fluid lost is a mixture of the various secretions containing essentially equivalents amount of sodium and chloride so that the problem does not arise, and even in the few cases in which an acid base disturbance does complicate the picture it rarely requires specific treatment.

A further complication is provided by the deficit of potassium which may arise as a result of severe losses from the alimentary tract. Potassium is lost through direct loss of electrolyte which is present in the stomach and intestinal secretions. Long continued vomiting or aspiration of stomach secretions results in a loss of intracellular fluids which contain potassium. Falconer observed that vomitus contains 5 times the concentration of potassium present in the serum. With loss of gastric secretions containing free HCC more chloride is lost than sodium with the production of alkalosis. The excess sodium in proportion to chloride in such states may go into the cell, displacing the potassium which is eliminated.

POTASSIUM DEPLETION

Develops for two reasons : (a) the loss from alimentary tract contains potassium 5 times than that of serum, (b) there is a constant loss of potassium from the kidneys, which do not conserve this ion even when the intake is zero ; further if the patient has to undergo an operation the loss in the urine will be greatly increased by the potassium diuresis which always occurs in the first 48 hours post-operatively.

Clinically, however, we have seen a rather diffuse symptom complex resembling that described by Ariel, Abels, Pack, Rhodes and Irenius consisting of drowsiness, langour, chronic ileus with moderate distension, anorexia and weakness frequently accompanied by some peripheral oedema and oliguria. Not all symtoms are present in any one case and the pattern is not altogether specific.

No definite pathologic changes attributable to potassium deficiency is known to occur in man other than oedema of cells in which sodium has replaced potassium but it is reasonable to assume that changes do take place in the cells as a result of marked water and electrolyte imbalance of which potassium constitutes an important part.

CONCLUSION

We have shown that in acute abdominal emergencies in man there is a tendency for the concentration of each of the three principle electrolyte of serum to decrease and this decrease is usually most apparent in the concentration of potassium. Potassium depletion should always be suspected in any patient who has abnormal losses over a period of days during which the intake of this ion is negligible or zero. Diagnosis is suggested by clinical symptom, and confirmed by the presence of characteristic E. C. G. changes or low serum potassium.

Although the need of saline solutions as adjuncts in the treatment of acute abdominal emergencies is widely recognised less attention is paid to the composition of the solution which should be employed. These observations suggest that it is more logical to employ solutions containing potassium than to use sodium chloride alone.

SUMMARY

Changes in the serum electrolyte in acute abdominal emergencies has been studied. Sodium and potassium estimated by flame photometry and chloride by chemical method. At the time of admission the serum electrolyte levels were found to be within normal limits in cases with short history ; in cases of long duration and associated with vomiting, the serum electrolyte was found to be low in most cases and high in few. During hospitalisation, if parenteral fluid therapy was continued longer, and no food was given by mouth the sodium and chloride levels tended to rise while potassium level fell. The fall of potassium level was more marked in cases with vomiting and gastric aspiration. Hypokalemia was seen in 13 cases out of which 10 died.

THE MIGRATION OF BROMINE IN SOME BROMO CARBONYL COMPOUNDS

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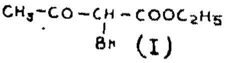
Ethylα-bromo acetoacetate (I) obtained by direct bromination of ethylacetoacetate [1] is unstable and passes into ethyl γ—bromo acetoacetate (II) on standing. Bromine in ethylαα—dibromo acetoacetate (III) undergoes similar migration [2] to give ethyl αγ—dibromo acetoacetate (IV).

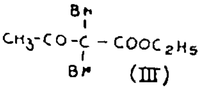


$CH_3-CO-\underset{Br}{CH}-COOC_2H_5$

(I)

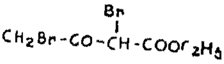
$CH_2Br-CO-CH_2COOC_2H_5$

(II)



$CH_3-CO-\overset{Br}{\underset{Br}{C}}-COOC_2H_5$

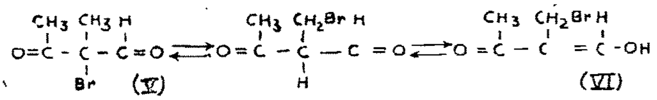
(III)



$CH_2Br-CO-\overset{Br}{CH}-COOC_2H_5$

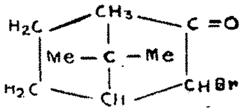
(IV)

Bokadia and Deshpande [3] have observed a similar migration in α- bromo α-formyl methyl ethyl ketone (V) which behaves as an enol (VI) and absorbs bromine. (V) cannot enolise unless there is an exchange of positions between bromine and hydrogen.



$$O=\overset{CH_3}{C}-\overset{CH_3}{\underset{Br}{C}}-\overset{H}{C}=O \rightleftharpoons O=\overset{CH_3}{C}-\overset{CH_2Br}{\underset{H}{C}}-\overset{H}{C}=O \rightleftharpoons O=\overset{CH_3}{C}-\overset{CH_2Br}{C}=\overset{H}{C}-OH$$

(V) (VI)

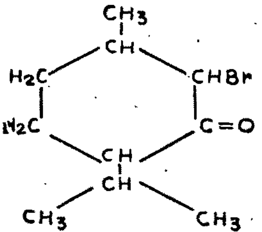


(VII)

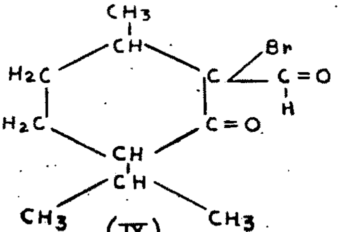
Generally α-bromo ketones in which bromine is attached to carbon directly connected to a carbonyl group, undergo 'inverse substitution' and liberate 2 atoms of iodine when treated with acidified potassium iodide. For example, in compounds such as ω-bromo acetophenone (C_6H_5-CO-CH_2Br), α-bromoethylacetoacetate (I) and γ-bromo ethyl acetoacetate (II), bromine is attached to carbon directly connected to a carbonyl group. It has no room to migrate to any position away from carbonyl, and it liberates 2 atoms of iodine from acidified KI.

$$C_6H_5-CO-CH_2Br \xrightarrow{HI} C_6H_5COCH_3+Br+I \longrightarrow C_6H_5CO.CH_3+I+I$$

In this article, the author describes the migration of bromine in two more carbonyl compounds *i. e.*, in α-bromo menthone (VIII) and α-bromo α-formyl menthone (IX). The former behaves like bromo-camphor and does not liberate iodine from acidified KI and the latter behaves like ∝-bromo ∝-formyl methyl ethyl ketone (V). It behaves as an enol and absorbs bromine.

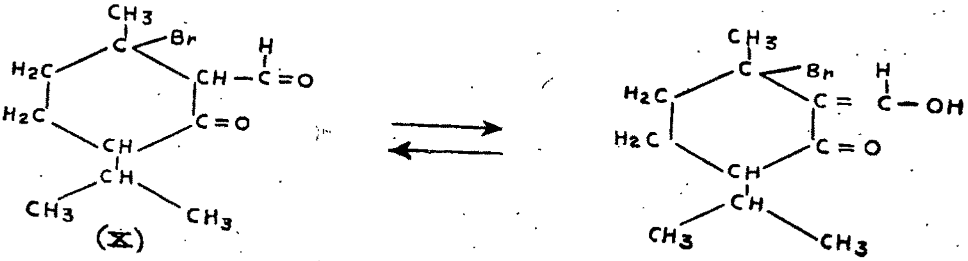


(VIII)



(IX)

Migration of bromine in (IX) probably produces (X) which can then enolise.



(X)

EXPERIMENTAL

Preparation of ∝-bromo ∝-formyl menthone :—

A mixture of menthone (15.4g) and ethyl formate (9g) was added in instalments to a suspension of sodium dust (2.8g) in dry benzene. The mixture was kept in ice-chest for about two days to complete the reaction. The sodium salt was filtered at the pump, washed with dry ether and suspended in CCl_4 and cooled well in ice-bath. To this suspension, a solution of bromine in CCl_4 was added in instalments till it was just in excess. The sodium bromide thus precipitated was filtered out and CCl_4 was removed on water-bath. ∝-bromo ∝-formyl menthone obtained was kept in a freezing mixture at a temperature of-10°C, but was not solidified. (Found: Br=31.0% whereas $C_{11}H_{17}O_2Br$ requires Br=30·6%).

Copper Salt of ∝-bromo ∝-formyl menthone was prepared and copper estimated in it. (Found : Cu=12.9% whereas $C_{22}H_{32}O_4Br_2Cu$ requires Cu=12.3%).

Preparation of ∝-bromo menthone :—

It was prepared by Bruhl's method [4]. A 10% solution of NaOH was added to ∝-bromo ∝-formyl menthone in excess. A yellowish emulsion was obtained which was extracted by dry ether. The ethereal layer after removal was dried over fused calcium chloride. ∝-Bromo menthone was obtained after distilling off ether.

SUMMARY

∝-bromo menthone and ∝-bromo ∝-formyl menthone unlike ∝-bromo ketones do not liberate iodine when treated with acidified KI. It is, therefore, suggested that bromine has migrated away from the carbonyl group by a rearrangement process.

ACKNOWLEDGEMENT

The author's thanks are due to Dr. S. S. Deshapande M. Sc., Ph. D. (London), F.R.I.C. (London) for suggesting the problem and his keen interest in the work.

REFERENCES

(1) Conrad and Schmidt, *Ber.*, 1896, **29**, 1044.
(2) Schonbrodt, *Annalen*, 1889. **253**, 175.
(3) Bokadia and Deshapande, *J. I. C. S.* 1957, **34**, 867.
(4) Bruhl, *Ber.*, **37**, 2177.

FORMYLATION OF SOME CHLORO ESTERS

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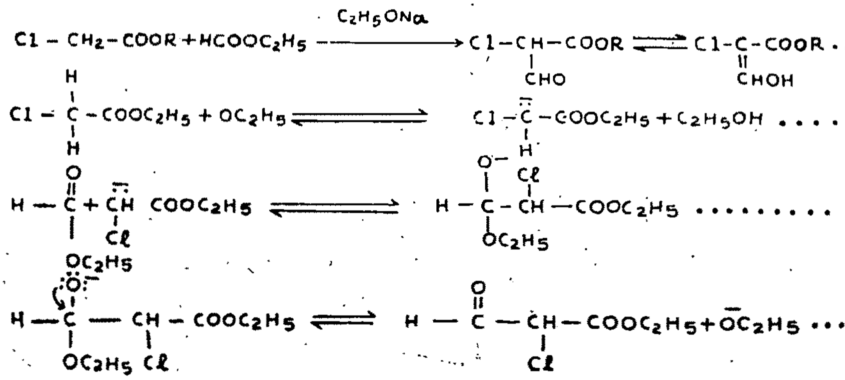
Arndt and Eistert (1); Renfrow and Hauser (2); and Hudson, Dick and Hauser (3) have shown that β-ketoesters by Claisen's condensation are obtained through the formation of carbanion intermediates. The same mechanism can be applied for the formylation of halogen esters *i.e.*, the reaction of ethylformate on halogen esters in presence of sodium ethoxide:



$$Cl-CH_2-COOR+HCOOC_2H_5 \xrightarrow{C_2H_5ONa} Cl-\underset{CHO}{CH}-COOR \rightleftharpoons Cl-\underset{CHOH}{\overset{}{C}}-COOR \tag{1}$$

$$Cl-\underset{H}{\overset{H}{C}}-COOC_2H_5+\bar{O}C_2H_5 \rightleftharpoons Cl-\underset{H}{\bar{C}}-COOC_2H_5+C_2H_5OH \tag{2}$$

$$H-\underset{OC_2H_5}{\overset{O}{C}}+\underset{Cl}{\bar{C}H}\ COOC_2H_5 \rightleftharpoons H-\underset{OC_2H_5}{\overset{O^-}{C}}-\underset{}{\overset{Cl}{CH}}-COOC_2H_5 \tag{3}$$

$$H-\underset{OC_2H_5}{\overset{:\ddot{O}:^-}{C}}-\underset{Cl}{CH}-COOC_2H_5 \rightleftharpoons H-\overset{O}{C}-\underset{Cl}{CH}-COOC_2H_5+\bar{O}C_2H_5 \tag{4}$$

The carbanion formed at stage [2] adds across the carbonyl double bond of ethyl formate and the ethoxide ion is expelled as in stage [4].

Pathak, Singhal and Bokadia (4) have studied the carbanion formation in some halogen esters.

In the present article, the formylation of chloromethyl acetate, Chloropropyl acetate and chloro butyl acetate has been described and some of the reactions of these formyl chloro esters have also been recorded.

EXPERIMENTAL

Synthesis of formyl chloro methyl acetate by condensation of chloro methyl acetate and ethyl formate in presence of sodium ethoxide:—

A mixture of chloro methyl acetate (15g) and ethyl formate (10g) was taken in equimolecular proportions. This mixture was added in small amounts to a well cooled suspension of sodium ethoxide (5g) in dry ether. The contents were kept overnight at 0°C to complete the reaction. The sodium salt of formyl chloro methyl acetate was filtered at the pump, washed well with ether and then suspended in ice and decomposed with dilute sulphuric acid. The product thus obtained was extracted with ether and dried over anhydrous sodium sulphate. After removal of ether on waterbath, the liquid was fractionally distilled under reduced pressure and the fraction collected in the range 116-119° at 95 mm solidified when kept over night at 0°C. On crystallisation from benzene, the substance was found to melt at 95°C. Yield 7 g. (Found: C, 35.00; H, 3.9; Cl, 25.4; $C_4H_5O_3Cl$ requires C, 35.27; H, 3.66; Cl, 26.01 per cent).

Synthesis of formyl chloro methyl acetate by the chlorination of the sodium salt of formyl methyl acetate:—

The sodium salt of formyl methyl acetate was prepared by condensing methyl acetate (12 g) with ethyl formate (8 g) in presence of sodium ethoxide (4 g) in cold. The sodium salt was filtered at the pump, washed with dry ether and dried over a porous plate. It was suspended in dry carbon tetrachloride and cooled in ice. Requisite amount (1 mol.) of chlorine was bubbled slowly through the suspension till the mixture became colourless. After the recovery of carbon tetrachloride, the liquid was distilled at reduced pressure and the fraction collected in the range of 116-119°/95 mm. was solidified when kept for some time in a refrigerator. The solid was crystallised which was found to melt at 95°C. Yield4 g.

Formyl chloro methyl acetate is a colourless crystalline solid (m. p. 95°C). It gives a violet colour with ferric chloride solution; reduces Fehling's solution ; oxidises acidified potassium iodide solution and produces blood red colour with a clear solution of ferrous sulphate and potassium thiocyanate.

Synthesis of formyl chloro propyl acetate by condensation of chloro propyl acetate with ethyl formate in presence of sodium ethoxide:—

Chloropropylacetate (12 g) was condensed with ethyl formate (6.5g) in presence of sodium ethoxide (4g) in the same manner as in the case of chloro methylacetate. The liquid obtained after removal of ether was fractionally distilled under reduced pressure and the fraction collected in the range of 145-150°/100 mm. was solidified on keeping it in a refrigerator. On crystallisation from dry benzene, it was found to melt at 98° C. Yield 5g. (Found: C, 44. 00; H,5.8 ; Cl, 21. 34; $C_6H_9O_3Cl$ requires C,43.76; H,5.47; Cl,21.58 per cent).

Formyl chloro propyl acetate was also prepared by the chlorination of the dry sodium salt of formyl propyl acetate in the same manner as in the case of formyl chloro methyl acetate.

Formyl chloro propyl acetate is a colourless crystalline solid (m.p. 98° C). It gives a violet colour with ferric chloride solution; reduces Fehling's solution;

oxidises acidified potassium iodide solution liberating iodine and gives a blood red colour with a colourless solution of ferrous sulphate and potassium thiocyanate. It is soluble in ether, benzene and alcohol but practically insoluble in water.

Synthesis of formyl chloro butyl acetate by condensation of chloro butyl acetate and ethyl formate in the presence of sodium ethoxide:—

Chloro butyl acetate (18g) was condensed with ethyl formate (10g) in the presence of sodium ethoxide (6g) in the same manner as described in the case of chloro methyl acetate. The liquid obtained after the removal of ether was distilled at 140° C/92 mm. On crystallisation from benzene, it was found to melt at 101° C. Yield 10g. (Found: C,47.01; H,5.9; Cl,19.03; $C_7H_{11}O_3Cl$, requires C,47.05; H,6.16; Cl,19.89 per cent).

Formyl chloro butyl acetate was also prepared by the chlorination of the sodium salt of formyl butyl acetate.

Formyl chloro butyl acetate is a colourless, crystalline solid (m.p.101°C). It gives a violet colour with ferricchloride solution; oxidises acidified potassium iodide solution, and gives a blood red colour with a colourless solution of ferrous sulphate and potassium thiocyanate.

It is very interesting to observe that formyl chloro methyl acetate, formyl chloro propyl acetate and formyl chloro butyl acetate like other enolic compounds do not give copper chelates when treated with a solution of copper acetate. The same observation (5) was made earlier by one of us (D.R.G.) in the case of formyl bromo ethyl acetate whose enol content could not be determined by Hibber's copper acetate method, as it did not form copper chelate when treated with copper acetate solution. As these formyl chloroesters do not form copper chelates, it is probably due to the fact that they exist in trans-enol forms.

During the process of formylation of these chloro esters; it is logical to think that some side reactions such as polymerisation, self condensation and Wurtz type of reaction etc. may also take place, but considering the fairly high yield of these formyl chloro esters, it remains little doubtful to consider that formylation is the major reaction when the halogen esters are treated with ethyl formate in the presence of sodium ethoxide.

Further work is in progress to determine the enol content of these formyl chloro esters.

References

1. Arndt and Eistert, 1936, *Ber.*, **69**, 2381.
2. Renfrow, W. B. and Hauser, R. Charles, 1938, *J. Am. Chem. Soc.*, **60**, 463.
3. Hudson, B. E., Jr., Dick, R. H. and Hauser, R. Charles, 1938, *J. Am. Chem. Soc.*, **60**, 1960.
4. Pathak, H. D., Singhal, G. C. and Bokadia, M. M., 1958, *J. Vik. Univ.*, **2**, 160.
5. Gupta, D. R., 1949, *M. Sc. thesis of the Agra University*; 1960, *Bull. Acad. Polon. Sc.*, **8** (**4**), 77.

ENOL CONTENT OF HALOGEN FORMYL ESTERS

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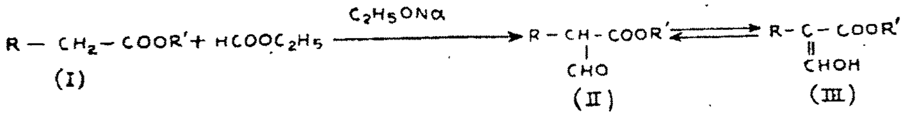
INTRODUCTION

By the action of ethyl formate on esters (I) in presence of sodium ethoxide α-aldo-esters (formyl esters) (II) are formed :



$$\underset{\text{(I)}}{R-CH_2-COOR'} + HCOOC_2H_5 \xrightarrow{C_2H_5ONa} \underset{\text{(II)}}{R-\underset{CHO}{\underset{|}{CH}}-COOR'} \rightleftharpoons \underset{\text{(III)}}{R-\underset{CHOH}{\underset{\|}{C}}-COOR'}$$

It was observed by Claisen[1] that the compounds (II) are strongly acidic and exist in the enolic form (III).

The formyl derivatives of most of the esters are unstable and undergo self condensation. It has, however, been observed that formyl derivatives of halogen esters are quite stable and strongly enolic like formyl ketones.

The enol contents of chloro formyl methyl acetate, bromo formyl methyl acetate, chloro formyl ethyl acetate, bromo formyl ethyl acetate, β-chloro-α-formyl ethyl propionate and chloro formyl butyl acetate have been determined by K. H. Meyer's method[2,3] and communicated in the present article. An explanation for their stability and strongly enolic nature has also been given.

EXPERIMENTAL

Enol Contents By K. H. Meyer's Bromine Method—A weighed amount of the halogen formyl ester (.1—3 g) was dissolved in absolute alcohol and cooled to -10°C. To this solution was added an alcoholic solution of N/5 bromine in slight excess. The excess of bromine was removed by adding alcoholic solution of α-naphthol (10%) until the pale yellow colour due to excess of bromine just disappeared. The whole operation was completed within 15 seconds and at -10°C. Potassium iodide solution (10%) was then added to the above solution and the mixture was warmed gently and the liberated iodine was titrated against N/10 sodium thiosulphate solution.

The halogen formyl esters have got an oxidising tendency and therefore liberate iodine by oxidising potassium iodide used in K. H. Meyer's method for the estimation of enols. The formyl chloro esters liberate iodine very slowly and the degree of oxidation depends upon the time of contact. β-chloro

α-formyl ethyl propionate possesses no oxidising property. While estimating enols by K. H. Meyer's method a correction has been applied for the oxidation of potassium iodide by the halogen compounds as recorded in table 1.

Table 1

Oxidation of KI due to the original halogen atom present in the halogen formyl esters (Blank Reading) :—

Compound	Weight (gms.)	Strength of Thiosulphate.	Titre (c.c.)
Formyl chloro methyl acetate	0.1594	0.1094 N	5.0
Formyl bromo methyl acetate	0.1321	0.1049 N	13.4
Formyl chloro ethyl acetate	0.1132	0.0881 N	3.5
Formyl bromo ethyl acetate	0.1860	0.1021 N	18.7
Formyl chloro butyl acetate	0.1858	0.1049 N	13.2

The enol contents of these halogen formyl esters have been recorded in Table 2.

Table 2

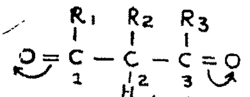
Enol contents of halogen formyl esters after correction for oxidation due to original halogen atom :—

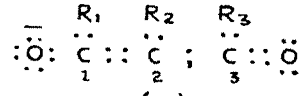
Compound	Weight	Strength of $Na_2S_2O_3$ Soln.	Total titre (c.c.)	Correction for the oxidation of KI due to the original halogen atom.	Titre due to enol	Enol %
Formyl chloro methyl acetate	0.1219	0.1049 N	17.5	3.9	13.6	79.8
Formyl bromo methyl acetate	0.1270	0.1049 N	22.4	12.8	9.6	73.0
Formyl chloro ethyl acetate	0.1035	0.0881 N	15.9	3.2	12.7	81.4
Formyl bromo ethyl acetate	0.1324	0.1021 N	23.7	13.3	10.4	78.2
Formyl chloro butyl acetate	0.1113	0.1049 N	16.4	7.9	8.5	71.5
α-Formyl-β-chloro ethyl propionate	0.1328	0.0881 N	...	...	10.8	58.7

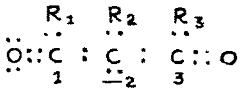
The enol contents of these halogen formyl esters could not be estimated by Hibber's method[4] as these esters do not form copper chelates.[5]

DISCUSSION

The mobility of a 1 : 3 dicarbonyl system (IV) is due to the displacement of electrons (electromeric change) caused by the two carbonyl oxygen atoms. On account of the tendency shown by the two carbonyl oxygen atoms to appropriate two out of the four common electrons, and to become negatively charged, the hydrogen attached to carbon atom No. 2 is less under the control of electrons between it and the carbon, and can, therefore, separate as a positive ion. The remaining anion has a structure such as (V) or (VI) :

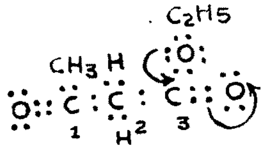

(IV)

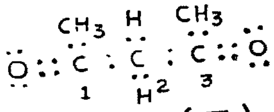

(V)


(VI)

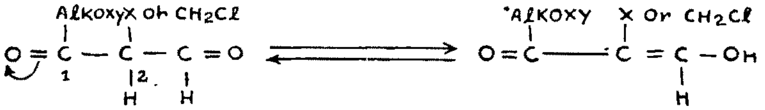
The removal of hydrogen as a proton thus produces two structures for the anion with either of which the proton may rejoin. If it joins with oxygen of the anion (V), the enol is formed ; if it joins to carbon of (VI) the keto form is produced.

The effect of groups R_1, R_2 and R_3 on the mobility of the system (IV) is very appreciable. In ethyl acetoacetate ($R_1=CH_3$, $R_2=H$, $R_3=-OC_2H_5$) the tendency of the carbonyl oxygen linked to carbon atom No. 3 to appropriate electrons to itself is opposed by the tendency of the singly bound oxygen of $-OC_2H_5$ to increase its CO— valency, and to supply electrons to the carbon. The mobility of the system is, therefore, weaker than the mobility in a 1 : 3 diketone such as acetylacetone (VII) ($R_1=CH_3$, $R_2=H$, $R_3=CH_3$) where R_3 does not oppose the tendency of the carbonyl oxygen.




(VII)

The enol percentage in ethyl aceto acetate is, therefore, much less than in acetyl acetone (79.1%, determined by one of us[5] by K. H. Meyer's method). Considering the structures of halogen formyl esters (IX) (R_1=Alkoxy group *i.e.*, $-OCH_3$, $-OC_2H_5$, $-OC_3H_7$, $-OC_4H_9$, R_2=halogen atom X or CH_2Cl in the case of β- chloro -α- formyl ethyl propionate, $R_3=H$), the occurrence of only one enol is expected namely that which corresponds to the oxymethylene form (X).



(IX) (X)

This is because the alkoxy group has a negative inductive effect (—I, release of electrons) in comparision with H and this —I effect slightly opposes the tendency of carbonyl oxygen attached to carbon atom No. 1 to become negatively charged. Hence carbonyl oxygen attached to carbon atom No. 3 is more likely to become negative, producing the oxymethylene structure (X).

The replacement of R_3 by hydrogen removes the slight —I effect of R_3 and allows full scope to the tendency of carbonyl oxygen to become negatively charged. It is expected, therefore, that the compounds (X) should have a high enol content. Moreover, in the molecules of halogen formyl esters (R_2=X, or CH_2Cl), the inductive effect of X, attached to carbon atom No. 2 facilitates expulsion of hydrogen attached to the same carbon as proton and should consequently lead to a higher enol content which has actually been observed.

It is interesting to observe that in the molecule of β- chloro -α-formyl ethyl propionate the inductive effect of the group -CH_2Cl is weaker than that of the halogen atom, and cosequently the enol content in this ester is lowest

REFERENCES

1. Claisen, 1889, *Ber.*, **40**, 2191.
2. Meyer, K. H. and Kappilmeir, P., 1911, *Ber.*, **44**, 2718.
3. Meyer, K. H., 1912, *Ber.*, **45**, 2843.
4. Hiber, 1921, *Ber.*, **54**, 902.
5. Gupta, D. R., 1949, *M. Sc., thesis of the Agra University, Agra.*

OCCURRENCE OF PLEUROPNEUMONIA-LIKE ORGANISMS IN POULTRY IN INDIA*

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The pleuropneumonia-like organisms (PPLO) belong to an apparently more or less homogeneous group of those fastidious micro-organisms which are filtrable, soft, fragile and highly pleomorphic. The first member of this group of organism was isolated by Nocard and his associates in 1898 from an infectious disease of cattle known as pleuropneumonia. The second organism of this group was described by Bridre and Donatien (1923, 1925), who isolated it from sheep infected with contagious agalactia. Since then a number of similar forms, both parasitic and saprophytic, have been isolated from different sources, particularly the respiratory and genito-urinary tracts of mice, rats, dogs, cattle and man. The existence of saprophytic organisms was demonstrated by Laidlaw and Elford in 1936 (Wilson and Miles, 1957).

Klieneberger in 1935 isolated organisms from stock cultures of *Streptobacillus moniliformis* which was believed by her in the beginning to be PPLO, living in symbiosis with the bacteria. Later, the classical investigation of Dienes (1939) and further studies of Heilman (1941) and Smith (1951) clearly demonstrated that these were dissociated forms of bacteria which are usually designated as 'L-forms' or 'L-phase' organisms. Soon after, so called 'L-forms' were isolated from many Gram positive and Gramnegative bacteria, such as *Proteus, Salmonella, Shigella, Haemophilus, Neisseria, Bacillus* and *Clostridium.* Further, it has been shown that many bacteria produce 'L-forms' as a result of injury or when exposed to unfavourable conditions such as penicillin and the presence of certain aminoacids. Antigenically 'L-forms' are closely similar to the organism from which they are derived. They also tend to revert to their original morphology under suitable conditions.

In 1936 Nelson described the association of coccobacilliform bodies with an infectious coryza of fowls. These coccobacilliform bodies and PPLO isolated by Markham and Wong (1952) from chronic respiratory disease (CRD) of chickens both are now believed to be the same organism (Stubbs *et. al.* 1954).

The first report of the isolation of PPLO from a human being appeared about forty years after the first isolation of these organisms from cases of bovine pleuropneumonia and it was in 1937 when Dienes and Edsall recovered these organisms from a woman's suppurating bartholin's gland (cited by Leberman *et. al.* 1950). Many reports have appeared since then on the isolation of PPLO from humans.

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* Paper presented during the First Scientific Session of Association of Microbiologists of India and is a portion of research work carried out by R. C. Pathak in partial fulfilment of the requirements for the degree of Master of Veterinary Science in Advanced Bacteriology of the Agra University.

The role of PPLO in the causation of the respiratory diseases of poultry though not completely established, the current view is to regard them as the constant and recognisable etiological factor in CRD of poultry (Crawley and Fahey, 1955, 1957), Chu, 1958a, b) and (Jungherr, 1958). Consiquently, the isolation and identification of the PPLO, and the study of serology have become necessary adjuncts in the diagnosis of PPLO infection of poultry.

In India the respiratory diseases are widely prevalent among poultry flocks maintained on organized Government poultry farms, but their etiology remains obscure. It appears that probably there is no report in the literature on the isolation and studies of PPLO from poultry in India prior to the preliminary reports of Pathak and Singh 1959 A and B.

Perhaps the isolation and identification of PPLO might unfold, to some extent, the concealed identity of the respiratory diseases of poultry, prevalent in the country.

MATERIALS AND METHODS

The birds used in this study mainly represent the breeding stock of four different State poultry farms of the country.

The details of the materials are as follows :

Poultry Farm attached to the U. P. College of Veterinary Science and Animal Husbandry, Mathura.

Number of carcases, showing lesions in the respiratory system, examined	..6
Number of live birds examined	
Breeding stock	..202
Progeny of the breeding stock	.. 40
Hatching eggs (embryos dead in shell)	.. 60

Heringhata Poultry Farm, Calcutta

Breeding stock	..30

Babugarh (Meerut) Poultry Farm

Breeding stock	..36

Bharari (Jhansi) Poultry Farm.

Breeding stock	..30
Progeny of the breeding stock	..28

Except the poultry farm attached to Heringhata Farm, Calcutta, about which the history is not known, all other three poultry farms have been exposed to some obscure respiratory diseases during the last few years. The poultry flock of the College Poultry Farm has also had the history of out-breaks of respiratory diseases for some time past. Previous work done in the Pathology and Bacteriology Department on the isolation of the causative agent by the chick embryo technique was indicative of probable involvement of infectious bronchitis virus. It has been the observation of the author for past few years that quite a few carcases of birds are received for routine post-mortem examination, throughout the year, which show slight to extensive involvement of the air sacs with lesions similar to that of the so called CRD. However, attempts could not be made earlier to isolate PPLO from the lesions of these birds dying due to this disease of respiratory system of chronic nature.

The birds examined for the presence of PPLO in this study are maintained on the College Poultry Farm as breeding stock for raising chicks for distribution in the State for development of poultry husbandry. In the months of June and July, 1958, again there was an outbreak reported on this poultry farm due to some respiratory disease.

The method of study for the isolation and propagation of PPLO were essentially the same as discussed by Taylor and Fabricant (1957) except for some minor changes in the preparation of the liquid medium (vide infra).

Inoculum :

Sterile cotton swabs on sterile applicator sticks were used to remove the exudate, if any, and a little of the surface epithelium from trachea of the individual bird. This was achieved by opening the beak of the bird by holding comb and wattles and introducing the sterile cotton swab into the trachea and gently rubbing it and moving it to and fro in the trachea. The swab was then introduced into a tube containing 5 ml. of sterile nutrient broth (pH. 6.8) and agitated thoroughly to suspend the adhering tracheal contents. The resulting suspension in broth was again mixed with a pipette and was the inoculum for primary inoculation of the liquid medium.

Liquid Media Propagation :

The medium used was similar to that described by Taylor and Fabricant (1957) except that sterile 20% horse serum was substituted for 1% PPLO serum fraction.

A description of this medium is as follows :—

(*i*)	Heart infusion broth (pH. 7.8) with phenol red as indicator. ..	800 ml.
(*ii*)	Sugars : Glucose, Maltose, Sucrose Mannitol or Lactose (1% final concentration) ..	10 gm.
(*iii*)	Sterile horse serum (20%) final concentration) ..	200 ml.
(*iv*)	Thallium acetate (1:1000 final concentration) ..	1 gm.

(*v*)	Penicillin G potassium Crystalline (final concentration 1,000 units per ml.)	.. 1,000,000 units.

Preparation of the medium :

One gram of thallium acetate was dissolved in 800 c.c of the broth which was autoclaved for 15 minutes at 15 pounds' pressure. Ten grams of sugar were then dissolved and the medium sterilized in Koch's sterilizer. By sterile technique 200 ml. of horse serum and 1,000,000 units of penicillin were added to the sterile broth.

The medium was distributed in sterile (approximately 3 c.c) 12×90 mm. test tubes over flame with sterile pipette.

Inoculation:

To one tube of each of the five sugar media described above, approximately 0.2 ml. of the inoculum was added. These were incubated at 37° C and observed daily for signs of fermentation as indicated by change of the phenol red colour to yellow.

Morphology :

All tubes in which fermentation occurred were examined for turbidity and sedimentation. Gram and Wright stained smears were made from fermented tubes to determine the presence of contaminating bacteria, the PPLO or both under oil immersion.

Solid-media propagation :

From the sugar media tubes showing signs of growth, subcultures were made on 20% horse serum agar plates. These were incubated at 37° C and observed daily for the presence of the growth of PPLO and colony characteristics were studied.

Study of colony characteristics :

In order to study the characteristics of the PPLO colonies, some of the colonies were stained by the method of Dienes. The procedure of staining the colonies of PPLO was that described by Dienes and modified by himself (Morton *et. al.* 1951c) as follows :

The stain used, contains 2.5 gm. methylene blue; 1.25 gm. Azure II; 10 gm. maltose and 0.25 gm. sodium carbonate in 100 ml. of water. With a cotton swab, the stain is applied in a thin film over the surface of the cover slip and allowed to dry. The stained cover slips were then stored for a month or two in a petri dish.

Agar blocks about 1 cm. square are cut out of the culture medium from areas containing suspected colonies of PPLO and placed colony side up on clean glass slide. A stained coverslip is then placed gently, stain side down, on to the agar block and sealed, with hot paraffin. The staining is complete within a few minutes. Bacterial colonies rapidly decolorize the stain whereas the colonies of PPLO retain the stain and appear blue upon examination under the low power of the microscope.

Criteria of PPLO :

In this preliminary work for the identification of PPLO, a few or more of the following criteria were taken into consideration in the recognition of a PPLO growth.

(1) In general, the change of phenol red colour to yellow and almost clear medium was indicative of the PPLO growth. Smears were also made from many of the tubes and stained by Gram's or Wright's method and examined for the presence of coccobacillary and filamentous bodies. This study also eliminated the chances of contamination with bacteria which could atonce be detected.

(2) The growth from the liquid media was also subcultured on 20% horse serum agar plates and examination of the plates made daily for the growth of PPLO.

(3) The characteristic appearance of the colony was also studied after staining them by the method of Dienes.

(4) Smears prepared from solid medium by gently rubbing the block of the enrichment agar medium with growth side on the clear grease-free slide after staining with Gram's or Wright's method revealed no regular rigid form as bacteria but coccoid, globular and small filamentous shapes were observed which were not clearly visible even at 1000 magnification.

(5) The colonies on repeated subcultures on enrichment agar medium gave characteristic colonial morphology.

(6) The growth could only be obtained when use of enrichment media was made.

(7) The colonies on the surface of the enrichment medium could not be completely removed by gently passing the platinum loop over them.

Serology :

The haemagglutination (HA) test was done with only 15 cultures of PPLO showing slow rate of growth and colony characteristics of the pathogenic type. The method was on similar lines as described by White *et. al.* (1954).

Preparation of the organisms :

Hundred ml. flasks containing 40 ml. of enrichment broth were used for the propagation of the strain. One ml. of the already grown culture was inoculated in each of the flasks, which were incubated at 37° C for about 48 to 72 hours. The cultures were then centrifuged at 3000 r.p.m. for half an hour. The broth was poured off and the organisms were resuspended in 2 c.c. of 0.85% saline at pH. 7·0. Starting with this suspension of organism (Antigen) serial two fold dilutions were made from 0 to 1:32 for use in HA and HI tests.

Preparation of chicken R. B. Cs. :

Chicken red blood cells used in the HA and HI tests were washed three times and resuspended at 0.5% concentration in 0.85% saline at pH. 7.0.

Immune sera :

Immune sera used for HI tests were received from Professor Dr. Wallace of Illinois University.

Procedure :

In the HA tests, 0.25 ml. of each dilution of the antigen and 0.25 ml. red blood cells were added to 0.25 ml. of saline at pH. 7.0.

In the HI tests undiluted serum was used instead of saline. The contents were thoroughly mixed and then the plates allowed to stand at room temperature for one hour before making a final reading.

HA was considered to be positive in those cups in which the red blood cells were rather uniformly dispersed at the bottom of cups of the perspex plate. HI or absence of HA consisted of compact, settled out red blood cells (buttons) in the bottom of the cups.

RESULTS

Isolation and Characterization of PPLO

The results of isolation of PPLO from various specimen are detailed below :

Table I

Name of the farm	Number examined		No. giving positive PPLO isolation	Percentage of PPLO isolations
Mathura poultry Farm	Carcases	6	6	100
	Live birds			
	White Leghorn	151	139	92
	Rhode Island Red	14	14	100
	New Hampshire	25	24	96
	Barred Plymouth Rock.	12	11	91

(*Continued on page 161*)

Table I

(Contd. from page 160)

Name of the farm	Number examined		No. giving positive PPLO isolation	Percentage of PPLO isolations
	Progeny			
	Chicks of 4 weeks to 2 months	20	4	20
	Chicks of 2 to 4 months	20	9	45
	Hatching eggs			
	Embryos dead on 13-21 day of incubation (pooled material from trachea, lung and air sacs)	60	7	0.1
Heringhata Farm	White Leghorn	15	11	73
	Rhode Island Red	15	6	40
Babugarh Farm	White Leghorn	36	24	66
Bharari Farm	White leghorn	30	28	93
	Progeny			
	Below 2 months	12	2	16
	Below 5 months	16	9	56

Results of sugar fermentation reactions of 188 cultures of PPLO isolated on primary inoculation in liquid media are given in table II.

Table II

Total number of cultures	Number of cultures producing acid in		
	Glucose only	Glucose and Maltose	Glucose, Maltose and Sucrose
188	20	61	107

Generally change of colour of the phenol red indicator was appreciable after 48-72 hours of incubation. Only acid without gas was produced in all cases.

The subcultures made from liquid media on the 20% horse serum agar were studied after 3-4 days of incubation at 37° C under low power of microscope to appreciate the growth character. The colonies appeared circular, translucent and raised. The size of the colonies was quite variable and the morphology of the individual colony was not clear at this magnification.

On the whole, size and rate of the growth of various PPLO strains was quite variable. Many of the PPLO colonies could be clearly seen by means of a hand lens in 48 hours of incubation while several others could only be appreciated after 72-96 hours of incubation and even then were comparatively much smaller. Figures 1 and 2 give the appearance of the two types of colonies after staining with the method of Dienes. On several occasions these two types of colonies were seen in the same culture, that is, widely separated bigger colonies had between them smaller colonies growing comparatively late.

In enrichment broth there was no turbidity or sedimentation even after third or fourth day of incubation.

Smears prepared from solid or liquid media and stained by Gram's method or Wright's method did not reveal very clear morphology. Very small coccoid and filamentous bodies could be seen at about 1000 magnification.

Serology :

HA test was done with seven strains of PPLO collected from fowls of college poultry farm and eight strains from fowls of Bharari (Jhansi) Poultry Farm. All the 15 strains used in HA test were characterized by their slow growth rate and preponderance of colonies of smaller size as in Fig. 2.

Results of HA tests are shown in table III and of HI tests in table IV.

A positive sign indicates haemagglutination, while a negative sign indicates haemagglutination-inhibition or no haemagglutination as the case may be.

Table III

Showing HA tests with various strains.

Description of culture	Dilutions of antigen						
	Undiluted	1 : 2	1 : 4	1 : 8	1 : 16	1 : 32	Control
College Poultry Farm							
StrainNo. 1	+	—	—	—	—	—	—
2	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—
4	+	+	—	—	—	—	—
5	—	—	—	—	—	—	—
6	+	—	—	—	—	—	—
7	—	—	—	—	—	—	—
Bharari Poultry Farm							
StrainNo. 1	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—
3	+	+	+	—	—	—	—
4	+	—	—	—	—	—	—
5	+	+	—	—	—	—	—
6	+	—	—	—	—	—	—
7	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—

Table IV

Showing HI tests with only 4 strains which gave+HA tests.

(The antiserum used is the immune CRD serum supplied by Dr. Wallace of Illinois.)

	Dilutions of antigen					
	Undil.	1 : 2	1 : 4	1 : 8	1 : 16	Control
College Strain No. 1	—	—	—	—	—	—
College Strain No. 4	—	—	—	—	—	—
Bharari Strain No. 3	—	—	—	—	—	—
Bharari Strain No. 5	—	—	—	—	—	—

DISCUSSION

The results of isolation and propagation of the pleuropneumonia-like organisms from the tracheas of fowls in this study support the contention of Taylor and Fabricant (1957) that the liquid media inoculation is a sensitive method for the cultivation of PPLO.

Previously, yolk sac inoculation of embryonated eggs has been the accepted and classical method for the isolation and propagation of PPLO. But this technique requires an elaborate establishment involving expenditure and space, and is also time consuming. Besides, a constant supply of eggs from disease free hens must be at hand. Considering the prevalence of respiratory diseases of ill defined etiology in our country and knowing that many of these are egg borne namely infectious bronchitis, New castle disease and chronic respiratory disease, etc., it is in itself a problem to procure eggs suitable for the isolation and propagation of the causative agents of these diseases. The observation of Van Heric and Eaton (1945) that in the course of passaging a strain of the virus of primary atypical pneumonia amniotically in the developing chick embryo, an unidentified PPLO was isolated, also contraindicates the use of eggs from unknown source. Moreover, with multiple infections involving both the PPLO and embryocidal virus, it is never safe and sure to exactly know what one is getting is due to either or both of the agents involved.

The liquid media approach, particularly in this study, has more than one advantages. *Firstly*, the technique is inexpensive and relatively quick method of cultivation of PPLO. *Secondly*, the use of phenol red is very helpful in indicating the growth of PPLO. *Thirdly*, it also eliminates the danger of simultaneous involvement of any viral agent which may vitiate the results. *Fourthly*, the liquid media technique can be used in field conditions with a little establishment.

The figures of isolation presented in tables III and IV reveal that adult birds of the College and Bharari poultry farm gave isolation of PPLO from over 90% of the birds examined. Although no comparative technique like egg inoculation was simultaneously followed in this study, yet it is apparent from the percentage of PPLO isolation from adult birds, that the method is quite efficient and sensitive. The findings of Taylor and Fabricant (1957) further confirm the success of the liquid media method, who showed that isolation of PPLO from 120 chicken tracheas resulted in 68 isolations by the liquid media cultivation of which 24 were successful only by this method and 52 isolations were obtained by yolk sac inoculation of which 7 were successful only by this method. More recently liquid media like PPLO broth (Difco) have been extensively used by several workers including Yamamoto and Adler (1958a, b), Adler *et. al.* (1958), Chu (1958 b).

Although the PPLO isolated in this study were not characterized, on the basis of pathogenicity tests yet on the basis of criteria described by Chu (1958 b) and Adler *et. al.* (1958), it was observed that most of the PPLO strains were predominantly of the non-pathogenic type from their growth and colony characters. Adler *et. al.* (1958) and Chu (1958 b) isolated PPLO from birds free of clinical signs of disease and also from birds with clinical CRD and reported the occurrence of nonpathogenic types of PPLO in majority of cases while pathogenic PPLO could be isolated only from a few cases. They have further suggested that apparently the nonpathogenic strains are widely distributed in birds and are confusing in the determination of the role of PPLO in CRD. Hence, the adequacy of the PPLO isolation as a diagnostic aid for CRD, proposed by Lecce and Sperling (1954) becomes doubtful. Moreover, the finding of Fahey and Crawley (1954 a) that an agent which appears to be a virus and which is apparently involved in the etiology of CRD, raises the fundamental issue to find out the exact role, PPLO plays in the pathogenesis of CRD. The significance of the presence of non-pathogenic types in birds with or without clinical signs of disease is also not clear (Adler *et. al.* 1958 and Chu, 1958 b). As such the isolations of PPLO from fowls reported in this study and its relationship with CRD and other associated respiratory syndromes needs further elucidation in Indian conditions.

The results of sugar fermentation of PPLO cultures examined here, are quite variable, though most of the strains fermented one or more of the sugars. The observation of Adler *et. al.* (1958) that there are strains of PPLO which do not ferment sugars, present a limitation in the use of isolation of PPLO by the liquid media technique. Probably a few strains might have been lost in the study due to this shortcoming. But drawbacks are also present in yolk sac method or any other technique employed to date (Taylor and Fabricant, 1957).

From the table II it is noted that majority of the PPLO strains ferment all the three sugars, *viz.*, glucose, maltose and sucrose. Considering the criterian that most of the pathogenic PPLO usually ferment these sugars and nonpathogenic do not (Adler *et. al.* 1958), (Yamamoto and Adler, 1958 b) and (Chu, 1958 b), the fermentation of these sugars by majority of the strains studied indicates the probable co-existence of pathogenic PPLO types. This can presumably be explained by the observation that slow growing smaller colonies of pathogenic types were present in between rapidly growing larger colonies, the former being capable of fermenting the sugars.

Examination of smears made from the cultures in liquid and solid media, after staining with Gram's or Wright's method under oil immersion(X1000) is not at all satisfactory. No definite morphology of the organism could be appreciated at this magnification. Magnifications of 2000 or more might be of use for better understanding of the morphology of PPLO.

Results of isolation of PPLO from breeding hens, young chicks and embryos in hatching eggs are indicative of direct transfer of this agent from the mother to the progeny through the eggs. This is in agreement with the findings of many previous workers including Fahey and Crawley (1954 b), Cover and Waller (1954) and Fabricant *et. al.* (1958). Fahey and Crawley (1954 b) have further suggested that from the experimental evidence reported, it should not be concluded that egg transmission is the only method of spread of PPLO. They have shown that PPLO infection also spreads by natural air borne route (Fahey and Crawley, 1955). Barger *et. al.* (1958) have also indicated that PPLO infection is considered air borne and contamination of feed, water and litter may be additional sources of infection. Perhaps this might be one of the reasons why percentage of isolations of PPLO from the older progeny of the infected breeding stock, is higher than that from younger chicks or the embryos, because the older the chick grows more chances it will have for contracting the infection. Besides, raising chicks on the same premises which abounds in PPLO infection might be another factor in the perpetuation of the infection on account of direct and indirect contact of the progeny with the infected breeding stock.

The presumption which needs further research work in this connection is that the eggs, from only those dams in which PPLO infection has extended to posterior portion of the abdominal cavity (*i. e.*, involving abdominal air sacs), carry PPLO from the infected surrounding viscera. On the other hand birds harbouring PPLO in the trachea or the upper respiratory passages, might not be transmitting the infection to eggs. This may also possibly explain the low recoverability of PPLO from the eggs and the progeny of the infected breeding stock.

From the limited work done to study the serology of PPLO strains isolated during this investigation nothing very significant can be said. The studies reveal two types of strains *i.e.*, HA + and HA— as given in the table III. This is in accordance with the findings of several other workers like Chu (1958 b), Yamamoto and Adler (1958 b) and Jungherr (1958) who have also suggested that HA+ strains are usually of high pathogenicity and HA− usually of low pathogenicity. According to Jungherr (1958) HA− strains represent serological loss variants which probably also exist in intermediate forms but are not found in known PPLO negative flocks. Thus they cannot be considered inocuous. As such the isolation of PPLO both HA+ and HA− from these flocks have got a definite significance which can not be overlooked in formulating any plan for eradication or control of respiratory diseases of poultry in the country.

The HI test has been employed as a diagnostic means in determining the PPLO infection in poultry by several workers *viz.*, Fahey and Crawley (1954. c), White *et. al.* (1954), Gianforte *et. al.* (1955) and Crawley & Fahey (1955). The immune CRD sera received from the United States gave complete HI test with four of the distinctly HA+ strains (Table IV). The application of HI test in this limited study indicates the desirability of adopting this technique in the determination of PPLO infection in the birds of organized poultry farms.

The initiation of this study and the findings reported in these pages, on the isolation and characterization of PPLO strains viz., rate of growth, size of the colony, sugar fermentation reaction and the serological studies, clearly indicate the prevalence of both pathogenic and nonpathogenic types of PPLO in the country. The future work on the epidemiological aspects of PPLO infection might unfold the relationship of these organisms in the so called "infectious coryza" in chickens in India.

Summary and Conclusions

Out of 298 apparently normal adult fowls of different poultry farms of the country, 257 were found to harbour PPLO in the trachea, by using liquid carbohydrate medium which appears to be a suitable medium for the primary isolation of PPLO from tracheas of fowls. Other advantages of the use of this medium are economy, simplicity and speed. It was found very suitable for use in primary isolation of PPLO from field cases where full laboratory facilities are not available.

PPLO was also isolated from 24 chicks of the progeny of the infected breeding stock out of 68 chicks and 7 specimens of embryos in hatching eggs, out of 60 specimens examined. This indicates that PPLO are probably egg transmitted.

The sugar fermentation reactions of the avian PPLO are quite variable. Two types of PPLO colonies were recognised, one bigger and rapidly growing the other smaller and slow growing. Nonpathogenic types of PPLO appear to be more prevalent than pathogenic types.

Serological studies on 15 strains showed that 8 strains were HA— and 7 were HA+ in low dilutions. High titre immune sera gave complete HI of 4 distinctly HA+ strains.

The evidence has been put forth that PPLO are widely distributed in poultry in India and need for study of its prevalence more exhaustively in all parts of the country stressed.

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REFERENCES

1. ADLER, H. E., J. Fabricant, R. Yamamoto and J. Berg. 1958. Symposium on Chronic Respiratory Disease of Poultry I Isolation and identification of pleuropneumonia-like organisms of avian origin. *Am. J. Vet. Res.* **19** : 440-447.
2. BARGER, E. H., L. E. Card and B. S. Pomeroy. 1958. "Diseases and Parasites of Poultry." Lea and Febiger. Philadelphia.
3. CHU, H. P. 1958 a. Pleuropneumonia-like organisms and respiratory diseases of poultry. *Vet. Rec.* **70** : 55-64.
4. CHU, H. P. 1958 b. Differential diagnosis and control of respiratory diseases of poultry. *Vet. Rec.* **70** : 1064-1078.
5. COVER, M. S. and E. F. Waller. 1954. The presence of chronic respiratory disease in pipped eggs. *Am. J. Vet. Res.* **15** : 119-121.
6. CRAWLEY, J. F. and J. E. Fahey. 1955. A proposed plan for the control of chronic respiratory disease of chickens. *Poultry Sci.* **34** : 707-716.
7. CRAWLEY, J. F. & J. E. Fahey. 1957. The use of the haemagglutination inhibition test for the control of PPLO infection of poultry. *J. Am. Vet. Med. Assoc.* **130** : 187-190.
8. FABRICANT, J., P. P. Levine, B. W. Calhek and H. E. Adler. 1958. Studies on egg transmission of PPLO in chickens. (Abstract of) Paper presented at the 7th annual meeting of the poultry science associaton. *Poultry Sci.* **37** : 1203.
9. FAHEY, J. E. & J. F. Crawley. 1954 a. Studies on chronic respiratory disease of chickens II Isloation of a virus. *Canad. J. Comp. Med.* **18** : 13-21.
10. FAHEY, J. E. & J. F. Crawley, 1954 b. Studies on chronic respiratory disease of chickens III Egg-transmission of a pleuropneumonia-like organism. *Canad. J. Comp. Med.* **18** : 67-75.
11. FAHEY, J. E. & J. F. Crawley. 1954 c. Studies on chronic respiratory disease of chickens IV A haemagglutination-inhibition diagnostic test. *Canad. J. Comp. Med.* **18** : 264-272.
12. FAHEY, J. E. & J. F. Crawley. 1955. Studies on chronic respiratory disease of chickens V. Airborne spread of the CRD agent. *Canad. J. Comp. Med.* **19** : 53-56.

13. Gianforte, E. M., E. L. Jungherr and R. E. Jacobs. 1955. A serological analysis of seven strains of PPLO from air sac infection in poultry. *Poultry Sci.* **34**: 662-669.

14. Jungherr, E. L. 1958. Symposium on chronic respiratory disease of poultry. IV. The control of chronic respiratory disease. *Am. J. Vet. Res.* **19** : 464-467.

15. Klieneberger, E. 1935. J. Path. & Bact. 40 : 93. Quoted by Wilson and Miles, 1957.

16. Leberman, P. R., P. F., Smith and H. E. Morton. 1950. The susceptibility of pleuropneumonia-like organisms to the invitro action of antibiotics; Aureomycin, Chloramphenicol, Dihydrostreptomycin, Streptomycin and Sodium Penicillin G. J. Urol. **64** : 167-173.

17. Lecce, J. G. and F. G. Sperling. 1954. Chronic respiratory disease I. The isolation of pleuropneumonia-like organisms as a diagnostic aid. *Cornell Vet.* **44** : 441-449.

18. Markham, F. S. and S. C. Wong. 1952. Pleuropneumonia-like organisms in the etiology o turkey siusitis and chronic respiratory disease of chickens. *Poultry Sci.* **31** : 902-904.

19. Morton, H. E., P. F. Smith, N. B. Williams and C. F. Eickenberg. 1951 c. Isolation of pleuropneumonia-like organisms from human saliva. A newly detected member of the oral flora. *J. Dental. Res.* **30** : 415-422.

20. Nelson, J. B. 1936 Studies on an uncomplicated coryza in the domestic fowl VI. Coccobacilliform bodies in birds infected with coryza of slow onset. *J. Exp. Med.* **63** : 515-522.

21. Pathak, R. C. and C. M. Singh. 1959 A. A Preliminary Report on the Isolation and Identification of Pleuropneumonia-like Organisms from Poultry. *Poultry Sci.* **38**: 956-959.

22. Pathak, R. C. and C. M. Singh 1959 B. Pleuropneumonia-like Organisms from Poultry in India. *Current. Sci.* **28** : 338-339.

23. Smith, P. F. 1951. Isolation of pleuropneumonia-like organisms from the throats of humans. *Science* **113** : 623-624.

24. Stubbs E. L., F. G. Sperling and J. G. Lecce. 1954. Chronic respiratory disease. *Proc. Tenth World Poultry Congr.* 244-246.

25. Taylor, J. R. E. and J. Fabricant. 1957. Studies on the isolation of the pleuropneumonia-like organisms of chronic respiratory disease of fowls. *Cornell Vet.* **47** : 112-126.

26. Van Heric, W. and M. D. Eaton. 1945. An unidentified pleuropneumonia-like organism isolated during passage in chick embryo. *J. Bact.* **50** : 47-55.

27. Wilson, G. S. and A. A. Miles. 1957. "Topley and Wilson's Principles of Bacteriology and Immunity" London, Edward Arnold (Publishers) Ltd. 4th. ed.

28. White, F. H., G. I. Wallace and J. O. Alberts. 1954. Serological and electron microscope studies of chronic respiratory disease agent of chickens and of turkeys sinusitis agent. *Poultry Sci.* **38** : 500-507.

29. Yamamoto, R. and H. E. Adler. 1958 a. Characterization of pleuropneumonia-like organisms of avian origin. I Antigenic analysis of seven strains and their comparative pathogenicity for birds. *J. Inf. Dis.* **102** : 143-152.

30. Yamamoto, R. and H. E. Adler. 1958 b. Characterization of pleuropneumonia-like organisms of avian origin II Cultural, biochemical, morphological and further serological studies. *J. Inf. Dis.* **102** : 243-250.

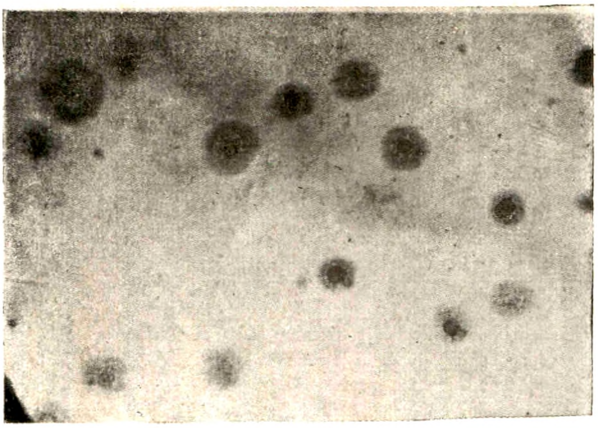

Fig. 1. Rapidly growing bigger colonies of avian PPLO on 20% horse serum agar plates after 72 hours of incubation at 37°C. 60x.

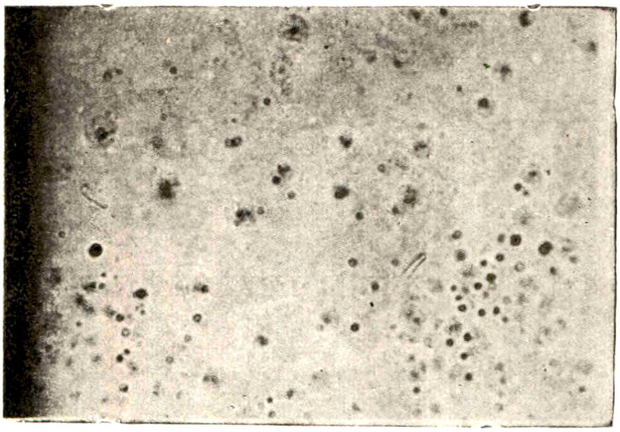

Fig. 2. Slow growing smaller colonies of avian PPLO under similar conditions as in Fig. 1. 60x.

STUDIES ON STAPHYLOCOCCI WITH PARTICULAR REFERENCE TO STRAINS FROM BOVINE UDDER.
V. PATHOGENICITY*

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Staphylococci are ubiquitous in nature and are normally present in different parts of the body including the skin of the udder and teats and body secretions like milk. The mere presence of Staphylococci in milk may not be singificant from pathological point of view and therefore, necessitates the desirability of distinguishing pathogenic from non-pathogenic strains on the basis of certain *in vitro* and *in vivo* tests.

A great deal of work has been done to distinguish pathogenic Staphylococci particularly of human origin. Source of isolation and various other properties like coagulase production, haemolysin production (particularly alpha lysin), pigment production, fermentation of mannitol, liquefaction of gelatin, production of filtrable toxins and their recognition on the basis of dermonecrotic and lethal effects and virulence test with cultures have all been studied critically. Few other properties like demonstration of leucocidin, fibrinolysin, enterotoxin, hyaluronidase, etc., have also been studied to some extent. The criteria of pathogenicity of Staphylococci are quite varied and different workers have been emphasising the importance of one test or the other.

The significance of coagulase test in differentiating pathogenic and non-pathogenic strains was realised by many workers eversince the test was first evolved by Loeb (1903-04) and Much (1908). Chapman *et al.* (1934, 1938) Hallman (1937), Cowan (1938), and others found coagulase production a very valuable tool in differentiating pathogenic from non-pathogenic strains. Several other workers (Moss *et al.* 1941; Kourilsky and Mercier 1942; Smith 1947; Elek and Levy 1950) found 100% correlation between coagulase production and pathogenicity of strains. Christie and Keogh (1940) and Pillet *et al* (1950) reported all strains, isolated from pathological lesions, to be coagulase positive. Lack and Wailling (1954) concluded that the absence of coagulase production was a strong indication of non-pathogenicity of a strain but there was no evidence that all coagulase positive strains were pathogenic. Although there was difference of opinion regarding the absolute correlation between coagulase production and pathogenicity yet large number of authors (Cruickshank 1937; Marcuccio 1938; Cowan 1938; Gillespie *et al* 1939; and others) recommended this test as the single reliable *in vitro* test.

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Chapman *et al* (1934) and Cruickshank (1937) stressed haemolysin production to be the second best criterion of pathogenicity. Smith (1947), Elek and Levy (1950) and Lack and Wailling (1954), attached little importance to alpha-lysin production in determining pathogenicity of a strain. Cowan (1938) and Gillespie *et al* (1939) found absolute correlation of alpha haemolysin and coagulase production with pathogenicity. Marks (1952) and Selbie and Simon (1952) considered alpha toxin production a more reliable criterion of pathogenicity than other *in vitro* tests. Schwabacher *et al.* (1945), Christie *et al.* (1946) and Williams and Miles (1949) found difference in alpha-lysin production between strains isolated from pathological and carrier sources.

The relative significane of chromogenesis with regard to pathogenicity of Staphylococci has been studied by several workers. The earliest work was done by Rosenbach (1884) who classified Staphylococci into aureus and albus types on the bases of pigment production. Chapman *et al.* (1934) considered chromogenesis an important criterion of pathogenicity in conjunction with coagulase and haemolysin production. Cruickshank (1937), Cowan (1938) and others found good correlation of aureus coloured strains with other important *in vitro* properties in determining pathogenicity excepting a few variations.

The fermentation of mannitol as an aid in differentiating pathogenic strains has received considerable attention. Gordon (1903-04) found that only those Staphylococci derived from infectious sources had the power to ferment mannitol. The findings of Dudgeon (1908) Hine (1922) and Dudgeon and Simpson (1928) conformed with that of Gordon. Other workers (Flaum 1938; Cowan 1938; and others) found good correlation of mannitol fermentation and pathogenicity of a strain. On the other hand Smith (1947) found appreciable number of non-pathogenic strains fermenting this substance.

Gelatin liquefaction is considered by some workers (Cruickshank 1937; Cowan 1938 and others) to be another property of pathogenic strains although in some cases non pathogenic strains were also seen to liquefy gelatin.

Barber *et al.* (1951) and Barber and Kuper (1951) found close correlation between coagulase and phosphatase production. Lovell (1958) showed that production of phosphatase can be used as an index of toxigenicity of Staphylococci.

The production of fibrinolysin was shown by several workers to be another property related to pathogenicity (Aoi 1932; Madison 1935-36 and Madison and Dart 1936). This property was mostly related to human pathogenic strains while animal strains showed this activity to a lesser extent (Christie *et al.* 1946 and Smith 1947).

Pathogenicity tests of Staphylococci in laboratory animals were carried out by different workers with variable results. Christie *et al.* (1946) and Selbie and Simon (1952) found pathogenicity in mice giving quite reliable results whereas Smith (1947), Lack and Wailling (1954) and Edwards and Rippon (1957) found less reliable results in mice both by the use of toxins and cultures.

The production of hyaluronidase, leucocidin, enterotoxin and the use of differential media were other tests of relatively less significance for the differentiation of pathogenic Staphylococci.

MATERIALS AND METHODS

Source of strains. In total 261 strains comprising of 167 from bovine milk samples, 10 from caprine milk samples, 1 from a case of ovine abscess and rest 83 milkers acting as normal carriers were studied. Bovine and caprine milk samples were taken from clinical, subclinical or healthy udders. One hundred thirty nine strains from Mathura, 84 from Lucknow, 29 from Madras and 9 from Calcutta constituted the total number of strains.

METHODS

Coagulase test. The tube technique described by Williams and Harper (1946) was followed :

One loopful of 24 hour old nutrient agar culture of each strain was emulsified in 1 ml. of rabbit plasma (diluted 1 in 10 of N. S. S.). The test was carried out in 7x1 cm. sized test tubes. The tubes were incubated at 37° C for 6 hours and observed at two hourly intervals. Positive and negative controls were employed simultaneously. The final readings were taken on next day morning after leaving the tubes over night at room temperature. Tubes showing no clot or showing only a granular appearance were recorded as negative, while those giving complete clots or clots with a little supernative plasma were noted as positive.

Haemolysis. The technique of Elek and Levy (1950) was adopted. Difco heart infusion broth with 0.2% KH_2PO_4, 0.03% $MgSo_4$ and 1.5% agar was used after adjusting the pH to 7.4. Twelve ml. medium with 4% washed rabbit and sheep RBC's was poured into separate plates. A filter strip 15 m. m. wide and of convenient length, soaked in commercial Staphylococcus antitoxin with 800 units per ml. (kindly supplied by M/S Burrough's Wellcome & Co.) was sunk into each plate before setting of the medium. After drying the plates three strains were streaked on each plate at right angles to the filter strip. Each strain was inoculated simultaneously on rabbit and sheep blood agar plates. The plates were incubated at 37° in 30% CO_2 and examined after 48 hours of incubation. Alpha haemolytic strains showed clear zones of haemolysis along the culture streak having blurred margins on both rabbit and sheep blood. Beta haemolysis was detected with incomplete haemolysis (at 37° C) and sharp margins showing action on sheep blood only. The alpha and beta haemolytic zones were completely inhibited due to antitoxic action at some distances (about 1 cm.) from the edges of the filter paper in the form of a wedge. Delta haemolysis was narrow, clear and sharp edged visible on both rabbit and sheep blood and was inhibited very slightly due to antitoxic action. Strains having different combinations were interpreted on these lines (Fig. I).

Pigment production. Pigment production of freshly isolated strains was noted on nutrient agar slants by incubating them at 37° C for 24-48 hours followed by keeping the tubes at room temperature for five days.

Fermentation of Mannitol. The tubes of peptone water containing 1% mannitol were inoculated with 2 drops of six hour old peptone water cultures; results were noted daily upto 3 days at 37° C incubation temperature.

Liquefaction of Gelatin. Two ml. of 20% gelatin medium was sown with 2 drops of 18 hour old broth cultures. The tubes were incubated for seven days at 37° C and kept for 30 minutes at 4° C before reading the results each day.

Phosphatase test. The technique of Barbar and Kuper (1951) was followed.

One per cent phenolphthalein diphosphoric acid was sterilized by Seitz filteration. One m. l. quantity of this solution was added to each 99 m. l. of melted nutrient agar (at about 55° C) to give a final concentration of 0.01%. Plates were poured and streaked with different strains after drying the surfaces. After 24 hour incubation at 37° C, the colonies of positive strains turned pink when exposed to ammonia vapours and results were noted immediately.

Fibrinolysin production. The plate technique of Christie and Wilson (1941) was adopted after slight modifications :

Measured quantities of 15% rabbit plasma was added in the clear melted nutrient agar at about 55° to 60° C and heated for 30 minutes at 56° C. The opaque medium thus obtained was poured in petri dishes in 12 m. l. quantities and allowed to set. The surfaces of the plates were dried in incubator with their lids half opened and spot inoculated. On a plate of average size 12 strains were inoculated and examined after 48 hours of incubation at 37° C. Fibrinolytic activity was recognised by clearing the opacity of the medium around the growths in the form of transparent rings.

Culture virulence test. Mice were injected intraperitoneally with 0.2 m. l. of washed 24 hour old broth cultures adjusted to opacity tube number 10 of Burroughs Wellcome Scale. Three mice were used for each strain and deaths were recorded over a period of one week.

Lethal toxicity test. The technique used was a modification of Walbum (1922) and Burnet (1931). Semisolid agar at pH 7.0 containing proteose peptone 1% KH_2PO_4 0.2%, $MgSo_4$ 0.03% and agar 0.4% in ox heart extract was used. Plates containing 15 m.l. of semisolid agar were inoculated and incubated for five days in 30% CO_2 tension. The medium in the plates was then chopped with sterile glass rods, filtered through cheese cloth and centrifused at 3000 r.p.m. for about half an hour. The supernatent from each tube was collected and used as toxin. The toxins thus prepared were more or less free from delta lysin due to long incubation period (Marks and Vaughan 1950). A set of 3 mice was injected intravenously with 0.4 m.l. of each toxin and deaths were recorded upto 48 hours.

Dermonecrosis. Diluted (1:20 in N. S. S.) and undiluted 0.2 m.l. quantities of each toxin were injected intradermally into the shaved portions on the backs of guinea-pigs or rabbits. The results were noted at intervals of 24 and 48 hours. Two toxins were tested on each guinea-pig and 3 on each rabbit (Fig. II).

RESULTS

Out of the total 167 bovine strains, only 48 strains were found coagulase positive and the rest 119 coagulase negative. On the basis of chrmogenesis, 53 strains were golden yellow, 86 white and 28 lemon yellow. Neither all aureus coloured strains were coagulase positive nor all coagulase positive strains were aureus coloured. Out of 53 golden yellow strains only 44 were coagulase positive. The percentage of coagulase positive albus strains was very low (4.7 per cent). All lemon yellow strains were coagulase negative. Out of forty-eight coagulase positive strains, 44 were golden yellow and 4 white.

The correlation of coagulase and haemolysin production was also not absolute. Out of 48 coagulase positive strains 45 were haemolytic, 1 weakly haemolytic and 2 non-haemolytic. Among 167 bovine strains under study 47 were haemolytic, 43 weakly haemolytic and 77 non-haemolytic. Forty five out of the 47 haemolytic strains, 1 out of 43 weakly haemolytic strains and 2 out of 77 non-haemolytic strains were coagulase positive.

It can be inferred from Table 1 that out of 47 haemolytic strains, 44 were golden and 3 porcelain white in colour. Among 53 aureus strains, 44 were haemolytic, 5 weakly haemolytic and rest 4 non-haemolytic. Three of the 86 albus strains were haemolytic, 32 weakly haemolytic and the rest 51 non-haemolytic.

The positive results of mannitol fermentation, gelatin liquefaction and phosphatase production were also given by large number of the so-called non-pathogenic strains in addition to the strains having haemolytic and coagulase properties. Out of 167 bovine strains, 135 fermented mannitol. Forty-seven out of 53 aureus coloured; 42 out of 48 coagulase positive and 41 out of 47 haemolytic strains fermented mannitol.

Table I

Correlation of important in vitro properties of bovine strains of Staphylococci.

	Pigment production			Coagulase production		Production of Haemolysins						Mannitol fermentation		Gelatin liquefaction		Phosphatase production.	
Total number of strains=167	Aureus	Albus	Cit-reus	+	—	Alpha beta	alpha delta	beta detla	alpha beta delta	W.H. *	N.H. **	+	—	+	—	+	—
Number of strains	53	86	28	48	119	9	2	26	10	43	77	135	32	120	47	90	77
Colour Aureus				44	9	9	2	25	8	5	4	47	6	50	3	45	8
Colour Albus				4	82	...	...	1	2	32	51	63	23	53	33	35	51
Colour Citreus				...	28	...	...	...	...	6	22	25	3	17	11	10	18
Coagulase Production						9	2	25	9	1	2	42	6	46	2	43	5
						...	..	1	1	42	75	93	26	74	45	47	72
Production of haemolysins. alpha-beta												9	...	8	1	8	1
alpha-delta												...	2	2	..	2	...
of beta-delta												23	3	26	...	25	1
alpha-beta-delta												9	1	9	1	8	2
*W.H.												31	12	29	14	20	23
**N.H.												63	14	46	31	27	50
Mannitol fermentation +														98	37	73	62
Mannitol fermentation —														22	10	17	15
Gelatin liquefactin +																80	40
Gelatin liquefactin —																10	37

N. B. * W.H.—Weakly haemolytic.

** N.H.—Non-haemolytic.

Table II

Relation of in vitro and in vivo characters of alpha and beta toxigenic strains having different haemolysin titres.

Haemolysin	Number of tested strians	Pigment production			Coagulase		Haemolysin titre	Lethal toxicity in mice*	Dermonecrosis on rabbits/g.piqs*		Culture virulence in mice*
		Aureus	Albus	Citreus	+	—			Undiluted	Diluted 1/20	
Alpha lysin	2	2	—	—	2	—	0—320	1/6	0/1	0/1	2/6
	2	2	—	—	2	—	640—1280	3/6	2/2	0/2	0/3
	4	4	—	—	4	—	2560&above	12/12	4/4	3/4	4/9
Total	8	8	—	—	8	—		16/24	6/7	3/7	6/18
Beta lysin	3	3	—	—	3	—	40—320	0/9	—	—	1/6
	3	3	—	—	3	—	—640	0/9	0/2	0/2	2/6
	3	3	—	—	3	—	—1280	0/9	0/2	0/2	1/6
Total	9	9	—	—	9	—		0/27	0/4	0/4	4/18

* Numerator indicates the number of mice died, (spot showing necrosis in case of dermonecrosis) while Denominator indicates number of mice tested (spots injected in case of dermonecrosis).

Gelatin was liquefied by 120 out of 167 bovine strains. Fifty out of 53 aureus coloured, 46 out of 48 coagulase positive and 45 out of 47 haemolytic strains liquefied gelatin. Out of 120 strains positive to gelatin liquefaction 98 fermented mannitol.

Ninety bovine strains were positive to phosphatase test. Forty-five out of 53 golden coloured strains, 43 out of 48 coagulase positive strains and 43 out of 47 haemolytic strains produced phosphatase.

Besides the above mentioned *in vitro* tests, certain *in vivo* tests were also carried out with a few selected strains to attempt their correlation. Seventeen bovine strains were divided into two groups *i.e.*, one group containing the alpha and the other containing beta toxigenic strains. The presence of delta lysin was eliminated due to longer incubation period (Marks and Vaughan 1950). Each group further consisted 3 sub-groups depending upon the titre of their haemolysins. All the strains were coagulase positive and aureus coloured. The lethal toxicity and dermonecrotic effects were found having correlation with the titres of alpha haemolysin, there being 100% mortality in mice in the titres of 1 : 1280 or above and all such toxins also produced dermonecrosis. Table II. Neither dermonecrotic nor lethal effect was observed by any of the beta toxigenic strains.

Alpha and beta toxigenic cultures killed six and four mice respectively from a group of 18 mice each. No exact correlation was observed between lethal toxicity and culture virulence tests.

The 10 caprine strains included in the study showed some interesting features. Although all the strains were isolated from clinical mastitis cases yet only 3 were coagulase positive and 2 were haemolytic (Table III). The rest weakly haemolytic strains showed better haemolysis on rabbit blood agar plates than on sheep blood. The haemolysins of these weakly haemolytic strains were also not inhibited by Staphylococcus antitoxin. One of the two haemolytic strains was coagulase negative. Both haemolytic strains produced alpha-delta type of haemolysis. All the caprine strains were off-coloured, fermented mannitol, liquefied gelatin within 48 hours and with the exception of one strain all others showed fibrinolytic activity on rabbit and sheep plasma agar plates.

Table III

In vitro and in vivo properties of caprine strains

No. of strains	Pigment		Haemolysis on plates			Coagul-ase		Manni-tol.		Gelatin		Fibrono-—lysin		Lethal toxicity @	Culture virulence test @
	+	—	Haem.	W.H	N.H	+	—	+	—	+	—	+	—		
10	10	—	2	8	—	3	7	10	—	10	—	9	1	5/20	4/20
	Off-coloured		alpha-delta												

W. H. — Weakly haemolytic
N. H. — Non-haemolytic
@ — Numerator indicates number of mice died and denominator number of mice tested.

Five out of 10 goat strains proved lethal to mice, 3 by virtue of their toxins and 2 by virtue of their cultures. One of the 3 lethal toxic strains was weakly haemolytic and was fatal to mice within two and a half hours of inoculation.

The human strains also showed certain departures from usual correlation limits of coagulase and haemolysins. Out of 83 strains 15 were coagulase positive but only 7 were haemolytic. Out of these 15 coagulase positive strains only 6 strains showed 100% correlation of aureus pigment, coagulase and haemolysin production (Table IV). The one remaining haemolytic strain was coagulase positive and off-coloured.

Table IV

Human strains showing relation of colour, coagulase and haemolysin production

Total strains = 83	Pigment production				Coagulase		Haemolysins					
	Aureus	Off-coloured	albus	Citreus	+	—	Alpha-beta	Alpha-delta	beta-detla	alpha-beta-delta	W.H	N.H.
Number of strains	9	5	68	1	15	68	1	1	4	1	14	62
Pigment production Aureus					7	2	1	3	1	1	—	3
Pigment production Off-col-oured					4	1	—	1	—	—	1	3
Pigment production albus					4	64	—	—	—	—	13	55
Pigment production citreus					—	1	—	—	—	—	—	1
Coagulase +							1	4	1	1	1	7
Coagulase —							—	—	—	—	13	55

W. H. — Weakly haemolytic
N. H. — Non-haemolytic

In the entire study, out of 50 haemolytic animal strains, 96% produced beta haemolysin in combination with other types of haemolysins ; on the other hand out of 7 haemolytic human strains 6 produced alpha haemolysin in other combinations.

DISCUSSION

Varied opinions have been expressed regarding the criteria on the basis of certain *in vitro* and *in vivo* tests for determining the pathogenicity of Staphylococci.

The results indicate that the value of mannitol fermentation, gelatin liquefaction and phosphatase production is limited and these tests do not serve to distinguish pathogenic from non-pathogenic strains. Although fairly large percentage of coagulase positive and haemolytic strains were positive to these tests, yet appreciable number of coagulase negative and non-haemolytic strains also gave positive results. The difference in the results by various workers is probably due to the variable incubation period and availability of the strains in all grades ranging from definitely positive to definitely negative.

Pigment production, though not as reliable as coagulase and haemolysin production, has shown importance next to these tests in distinguishing pathogenic from non-pathogenic strains. In this study 91.7% of coagulase positive and 93.6% of haemolytic strains were aureus coloured which compares favourably with the results given by other workers (Cruickshank 1937; Cowan 1938 and others).

Inspite of the fact that pigment producton is an easy and good criterion of pathogenicity, it has certain shortcomings. The colour can hardly be noticed immediately after getting the growth at 37° Cbecause it requires further keeping at room temperature for a few days to accentuate the intensity of the pigment. Also, the colour fades away in old cultures and sometimes different shades of colour are observed which cannot easily be assigned to any of the three recognised chromogenic groups. Lastly the albus strains isolated from pathological and carrier sources which do differ in their pathogenicity, can not be differentiated on this basis.

In this investigation the pathogenicity tests in laboratory animals did not prove to be very useful. Although two-third of alpha toxigenic strains were toxic to mice, none of the beta toxigenic strains proved lethal by virtue of its toxin. Only one-third of alpha toxigenic strains were lethal by virtue of their culture virulence. Smith (1947) and Edwards and Rippon (1957) did not put much weight on mouse pathogenicity tests. On the other hand Christie *et al.* (1946) and Pisu (1951) placed great reliance on these tests. Smith (1947) states, "more reliance placed on this test by Christie *et al.* (1946) may possibly account for their observation that some non-pathogenic strains produce coagulase, a finding whih is not borne out by the very large amount of work published by others on this subject".

The two most important properties of pathogenic strains mentioned are the production of coagulase and haemolysins (alpha and/or beta) production. There has been a lot of difference of opinion among workers regarding the superiority of one over the other.

In the present work there is good correlation between coagulase positive and haemolytic strains. Out of 48 coagulase positive bovine strains, 93.7% were haemolytic whereas out of 47 haemolytic strains 95.7% were coagulase positive. Cruickshank (1937) Cowan (1938), Smith (1947) and many others believed coagulase production to be the absolute criterion of pathogenicity of a strain. On the other hand Marks (1952), Selbie and Simon (1952) and others attached less importance to coagulase production and thought that alpha lysin production was more reliable. Schwabacher *et. al.* (1945) Christie *et al.* (1946), Williams and Miles (1949) and Marks (1952) found difference in alpha toxin production in the strains isolated from pathological and carrier sources, there being more alpha toxigenic strains in the former group. These workers disregarded the authenticity of coagulase production in determining the pathogenicity. On the other hand McFarlan (1938) and Smith (1947, 1954), found alpha lysin production in coagulase negative strains, which jeopardised the reliability of alpha lysin production as an index of pathogenicity. Other workers found non-haemolytic (Vaccaro *et al.* 1943) and coagulase negative (Mookerjee and Das 1947) strains from pathogenical lesions. It can be inferred from some of these reports that neither coagulase production nor alpha lysin production alone could be considered an absolute criterion of pathogenicity.

However, it may be pointed out that the difference in the results are probably due to the different techniques followed by different workers. Williams and Harper (1946) after adopting different techniques (Fisher 1936; Cruickshank 1937; Chapman *et al.* 1938; Cowan 1938; Gillespie *et al.* 1939; Fisk 1940) found coagulase positive results varying from 58 to 100%. This variation might have been responsible for certain coagulase positive strains being declared as doubtful or negative, which probably might have been haemolytic and pathogenic. Other factors leading to the difference in the results may be the use of plasmas from different species of animals, and the use of fresh or stored plasmas. Occasionally the presence of anticoagulants in the plasmas (Neter 1937) or accidental contamination of Staphylococcus cultures due to *B. coli* or *B. subtilis* (Fisher 1936), or the presence of non-specific substances in the cultures, may be other source of errors in the coagulase test.

Similarly the haemolysin test performed under different conditions may also give variable results. Williams and Harper (1947) and Elek and Levy (1950, 1954) found difference in the haemolysins, adopting plate and tube techniques. The former authors expressed inability to distinguish strains producing beta lysin alone from those producing both alpha and beta lysins on sheep blood agar plates. Similar difficulties may be encountered in recognising strains producing lesser amount of alpha and larger amount of delta toxins. Elek and Levy (1950) indicated that small quantities of alpha or beta haemolysins on blood agar plates can be masked by delta haemolysin. Occasionally, when a small amount of alpha haemolysin is produced, haemolysis may be absent on sheep blood agar and yet may appear as a small zone on rabbit blood agar (Elek and Levy 1950). Elek and Levy (1950) brought forward a new haemolysin among coagulase negative strains designated as epsilon which according to Mark (1952) is a non-specific lysin.

The anomalies in the coagulase and haemolysin tests mentioned above might have been responsible for showing superiority of one test over the other. By adopting the coagulase technique of Fisk(1940) and plate haemolysis of Elek and Levy (1950), fairly good correlation of coagulase and haemolysin production can be obtained and the chance of errors minimised. It can be inferred from the results in this study that the production of both coagulase and haemolysin (alpha or beta) is a very reliable indication of pathogenicity. On the other hand, the absence of anyone of these properties does not rule out the possibility of a strain being pathogenic. The source of isolation, pathological or otherwise, is another important and helpful factor in deciding the issue. Schalm and Woods (1953) considered the production of beta toxin and/or coagulation of rabbit plasma, the criterion of pathogenicity of udder Micrococci.

The strains isolated from caprine and human sources present some unusual characteristics. All the 10 caprine strains isolated from mastitis cases were off-coloured but only 3 were coagulase positive and 2 were haemolytic. All these were active gelatin liquefier, fermented mannitol and 8 were positive for phosphatase test. Nine out of 10 strains were fibrinolytic both on rabbit and sheep plasma and 5 were pathogenic to mice, 3 due to their toxins and another two strains by virtue of their culture virulence. It can be concluded from the above results that these strains were most probably pathogenic (Table III).

Thirteen out of 15 coagulase positive human strains were isolated from carrier milkers. Among the coagulase positive strains 7 were haemolytic, 6 of these showing 100% correlation between aureus pigment, haemolysin and coagulase production (Table IV). The findings of Schwabacher *et al.* (1945) and Christie *et al.* (1946) that there is no correlation between coagulase and alpha haemolysin production among the strains isolated from carrier sources is supported by the results of this study.

The significance of the presence of coagulase negative non-haemolytic or weakly haemolytic strains in the udder is an important point for consideration. Pande and Bakshi (1958) observed coagulase negative non-haemolytic Staphylococci in the udder transforming to coagulase positive and haemolytic strains within a period of two months, which proved pathogenic on animal inoculation. They also reported that these pathogenic albus strains were again observed to revert to non-haemolytic forms and lost the properties associated with pathogenicity. The percentage of coagulase negative and non-haemolytic or weakly haemolytic albus strains is quite large in this study (Table I). Such organisms may prove to be a potential source of infection to the udder particularly when the animal is exposed to predisposing factors.

SUMMARY AND CONCLUSIONS

1. All 261 strains isolated from bovine, caprine, ovine and human sources were tested for the criteria of pathogenicity on the basis of various *in vitro* and *in vivo* tests.

2. Mannitol fermentation, gelatin liquefaction and phosphatase production did not serve the purpose of distinguishing pathogenic from non-pathogenic strains because of the positive test being given by an appreciable number of non-pathogenic strains.

3. Pigment production can be used as a rough indication of pathogenicity. In this study 83% of golden yellow strains were coagulase positive.

4. Mouse pathogenicity is a criterion of pathogenic strains but all pathogenic strains are not lethal to mice. In this investigation two-third of alpha toxigenic strains were lethal to mice by virtue of their toxins and one-third by culture virulence. About 22% of the beta toxigenic strains were lethal to mice by culture virulence but were harmless by virtue of their toxins.

5. Coagulase and haemolysin production (alpha and/or beta) are very reliable tests for pathogenicity. These properties were found to have good correlation in this study, *i.e.,* 93.7% of coagulase positive strains were haemolytic and 95.7% haemolytic strains were coagulase positive. The presence of both these properties in a strain is a strong indication of its pathogenicity. On the other hand the absence of any of these does not rule out the possibility of a strain being pathogenic.

6. The probable source of errors in the results of coagulase and haemolysin tests have been discussed.

7. Strains isolated from caprine and human sources presented some departures from the usual correlation of *in vitro* properties of pathogenic strains. Out of 10 caprine strains isolated from mastitis cases only 3 were coagulase positive and 2 haemolytic. Only 7 out of 15 coagulase positive human strains were haemolytic.

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BIBLIOGRAPHY

1. Aoi, F. 1932. *Keta Sato Arch Exptl. Med.* **9** : 171. (Quoted by Blair, J. E. 1939. Bact. Revs. **3** : 97).
2. BARBER, M., Brookshank, B. W. L. and Kuper, S. W. A. 1951. *J Path. Bact.* **63** : 57.
3. BARBER, M. and Kuper, S. W. A. 1951. *J. Path. Bact.* **63** : 65.
4. BURNET, F. M. 1931. *J Path. Bact.* **34** : 471.
5. CHAPMAN, G. H., Berens, C., Nilson, E. L. and Curcio, L. 1938. *J. Bact.* **35** : 311.
6. CHAPMAN, G. H., Berens, C., Peters, A. and Curcio, L. 1934. *J Bact.* **28** :343.
7. CHRISTIE, R., Keogh, E. V. 1940. *J. Path. Bact.* **51** : 189.
8. CHRISTIE, R., North, E. A. and Parkin, B. J. 1946. *Aust. J. Exp. Biol. Med. Sci.* **24** : 73.
9. CHRISTIE, R. and Wilson, H. 1941. *Aust. J. Exp. Biol. Med. Sci.* **19** : 329.
10. COWAN, S. T. 1938. *J. Path. Bact.* **46** : 31.
11. CRUICKSHANK, R. 1937. *J. Path. Bact.* **45** : 295.
12. DUDGEON. L. S. 1908. *J. Path. Bact.* **12** : 242.

13. Dudgeon, L. S. and Simpson, J. W. H. 1928. *J. Hyg. Camb.* **27** : 160.
14. Edwards, S. J. and Rippon, J. E. 1957. *J. Comp. Path.* **67** : 111.
15. Elek, S. D. and Levy, E. 1950. *J. Path. Bact.* **62** : 541.
16. Elek, S. D. and Levy, E. 1954. *J. Path. Bact.* **68** : 31.
17. Fisher, A. M. 1936. *Bull. Johns. Hopk. Hosp.* **59** : 393, 415. (Quoted by Blair, 1939).
18. Fisk, A. 1940. *Brit. J. Exp. Path.* **21** : 311.
19. Flaum, A. 1938. *Acta. Path. Microbiol. Scand. Suppl.* **35** : I.
20. Gillespie, E. H., Devenish, E. A. and Cowan, S. T. 1939. Lancet, **II**. 870.
21. Gordon, M. H. 1903-04. Rept. Loc. Govt. Board., *Rep. Med. Officer* **33** : 388.
22. Hallman, F. A. 1937. Pro. Soc. *Exp. Biol. N.* Y. **36** : 789.
23. Hine, T. G. M. 1922. Lancet II : 1380.
24. Kourilsky, R. and Mercier, P. 1942. *Rev. Immunol.* **7** : 53. (Cited in *Vet. Bull.* 1946. 16 : Item no. 1927).
25. Lack, C. H. and Wailling, D G. 1954. *J. Path. Bact.* **68** : 431.
26. Loeb, L. 1903-04. *J. Med. Res.* **10** : 407. (Quoted by Cruickshank, 1937).
27. Lovell, H. R. 1958. *Nature.* **181** : 995.
28. Madison, R. R. 1935-36. *Proc. Soc. Exp. Biol. Med.* **33** : 209.
29. Madison, R.R. and Dart, E. E. 1936. *Proc. Soc. Exp. Biol. Med.* **34** : 299.
30. Marcuccio, G. 1938. *Riv. Sanit. Sicil.* **26** : 621. 625, 629. (Quoted by Wilson & Miles, 1955).
31. Marks, J. & Vaughan, A. C. T. 1950. *J. Path. Bact.* **62** : 597.
32. Marks, J. 1952. *J. Path. Bact.* **64** : 175.
33. Mc. Farlan, A. M. 1938. *Brit. Med. J.* **2** : 939.
34. Mookerji, A. and Das, M. S. 1957. *Ind. Vet. J.* **34** : 339.
35. Moss, E. S., Squires, G. V. and Pitts, A. C. 1941. *Amer. J. Clin. Path.* **2** : 857.
36. Much, H. 1908. *Biochem.* Z. **14** : 143. (Quoted by Cruickshank, 1937).
37. Neter, E. 1937. *J. Bact.* **34** : 243.
38. Pande, P. G. and Bakshi, S. N. 1958. *Science & Culture.* **24** : 135.
39. Pillet, J., Isbir, S. and Mercier, P. 1950. *Ann. Inst. Pasteur.* **78** : 638. (Cited in *Vet. Bull.* 1951. **21** : Item. 293).
40. Pisu, I. 1951. *Bull. Ist. Sieroter, Milano* **30** : 310.
41. Rosenbach, F. J. 1884. Wiesbaden. (Quoted by Wilson & Miles, 1955).
42. Schalm, O. W. and Woods, G. M. 1953. *Amer. J. Vet. Res.* **14** : 530.
43. Schwabacher, H., Cunliffe, A. C., Williams R. E. O. and Harper, G. J. 1945. *Brit. J. Exp. Path.* **26** : 124.
44. Selbie, F. R. and Simon, R. D. 1952. *Brit. J. Exp. Path.* **33** : 315.
45. Smith, H. W. 1947. *J. Comp. Path.* **57** : 98.
46. Smith, H. W. 1954. *J. Path. Bact.* **67** : 73.
47. Vaccaro, H., Perez, M. M. and Sepulveda, J. 1943. *Rev. Chill. Hig. Med. Prev.* **5** : 231.
48. Walbum, L. E. 1922. *Biochem. Zitschr.* **129** : 367. (Quoted by Flaum. 1938).
49. Williams, R. E. O. and Harper, G. J. 1946. *Brit. J. Exp. Path.* **27** : 72.
50. Williams, R. E. O. and Harper, G. J. 1947. *J. Path. Bact.* **59** : 69.
51. Williams, R. E. O. and Miles, A. A. 1949. *Med. Res. Council Spec. Rep. Ser. No.* **266** : London. P. 45-46. (Quoted by Marks, 1952).
52. Wilson, G. S. and Miles, A. A. 1955. *Principles of Bacteriology & Immunity.* 4th ed. Vol. **1** : Edward Arnold Ltd., London.

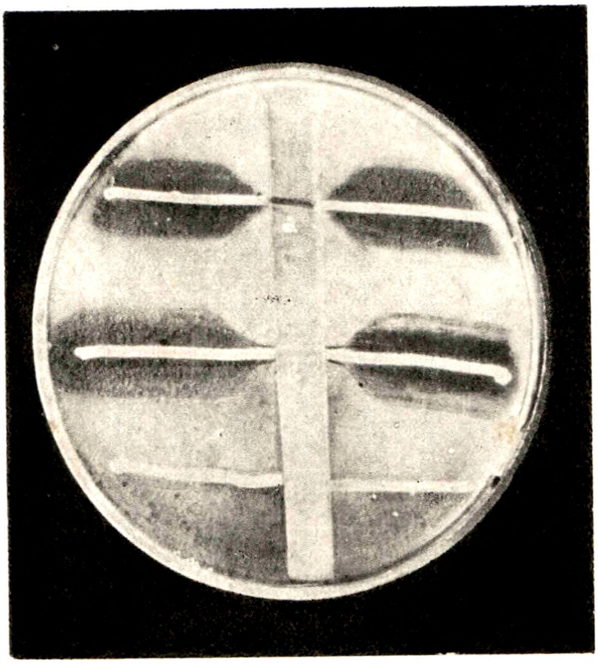

Fig. I. Haemolysis on sheep blood agar plate.

(a) Double zones of beta haemolysis.
(b) Alpha-beta-delta haemolysis.
(c) Non-haemolytic strain.

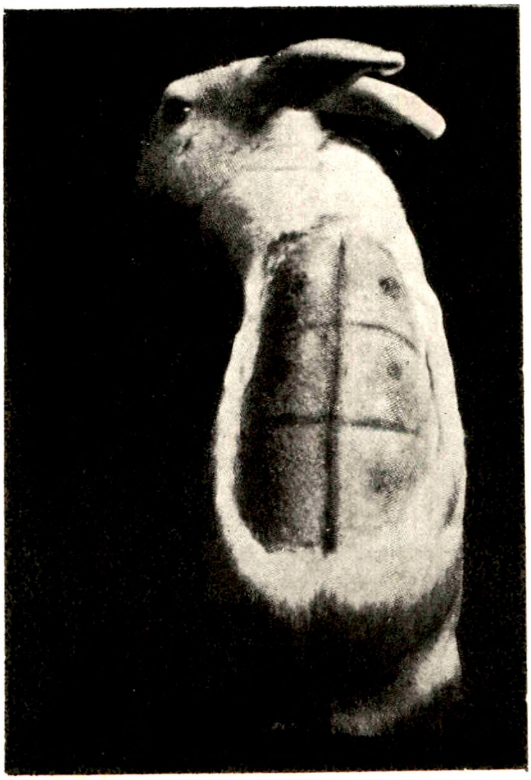

Fig. II. Rabbit showing demonecrosis due to alpha toxin.

ON THE INCIDENCE OF THE TINGID POPULATION IN AGRA*

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Contents

I. Introduction
II. Incidence
III. General Remarks
IV. Record of a species new to India
V. Distribution of Teleonemia scrupulosa
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INTRODUCTION

The Tingids, popularly known as 'Lace bugs' have attracted the attension of entomologists since time immemorial. The studies on the biology and immature stages of a few economically important species have fairly advanced in the hands of foreign and Indian workers. But we know practically nothing regarding their population, behaviour and the host plants of many already recorded species of Tingids, as in most cases the collections were made using light traps. Menon and Hakk (1959) recorded seven species of Tingids affecting garden plants in Delhi area. Roonwal (1953) made an extensive survey throughout India in order to estimate the rate of distribution of *Teleonemia scrupulosa* Stal.

An extensive survey on the Tingid population of Agra and its adjoining areas was carried out during the years 1958-60. In addition, special attention was paid to the specificity and the nature of damage caused to the host plants and the periodicity of attack. A few species occur throughout the year with differential population density during certain months while majority of the species recorded occur exclusively during the summer months. Only one species occurs exclusively during the winter months. Though most of the species recorded show marked specificity to the host plant a few have seasonals as host plants and in such cases migration from one plant to the other takes place irrespective of that plant being completely destroyed. Multiplication on one plant and migration to the other plants take place simultaneously. In Agra eleven species belonging to ten genera have been recorded by the author. The incidence and the density of population of each species and the damage caused to the host plants have been summarised in Table I and the population fluctuation in Graph I. St. John's College Garden, Agra was selected as the sample area to study the population density.

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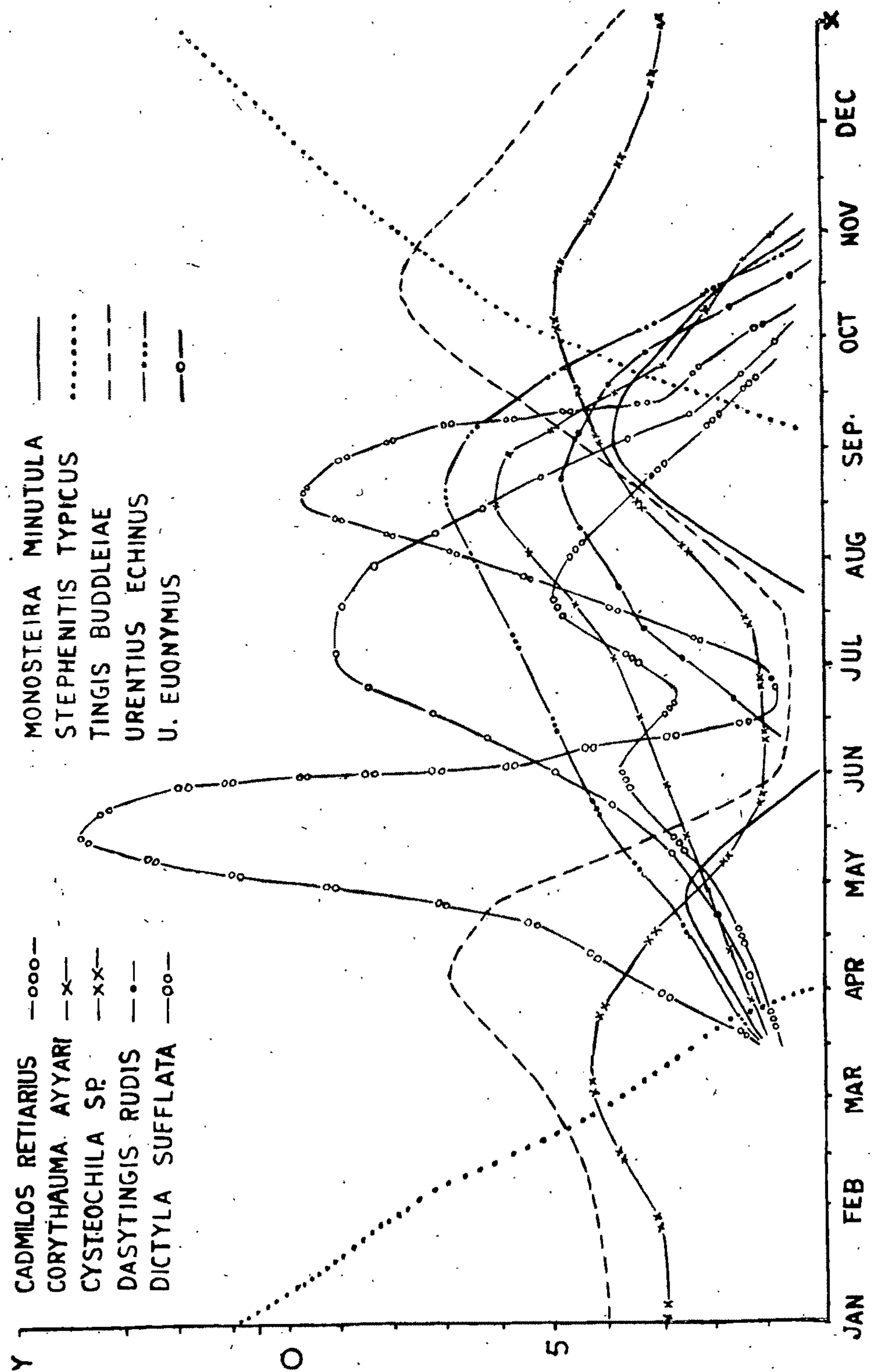
* Contribution No. 89 from the School of Entomology, St. John's College, Agra.

No.	Name of the species	Host plants	Nature of damage	Average number of adults on a single leaf during the year																							
				Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
1.	Cadmilos retiarius Distant (sym. Galeatus)	*Compositae* 1. Helianthus annuas. 2. Gaillardia 3. Daisy 4. Chrysanthemums 5. Marigold 6. Vernonia 7. Launaea *Papaveraceae* Argemone mexicana.	Attacks stems of succulent herbs, inflorescence, leaves and buds. Leaves get scorched crinkled. Damage serious.	0	0	0	0	0	1	2	2	3	5	4	3	3	3	4	5	4	2	1	0	0	0	0	0
2.	Corythauma ayyari (Drake.)	*Oleaceae* Jasminum SPP.	Attacks leaves and buds. Leaves crinkle with white corkish patches coated with bright sticky substance & later wither. Damage serious.	0	0	0	0	0	1	1	3	4	4	4	3	4	5	6	6	4	3	3	2	1	0	0	0
3.	Cysteochila delineata (Distant) (sym. Bredenbrachius)	*Caesalpinieae* Bauhinia	Buds get charred, brownish cork formation at the basal region of veins. Damage not serious.	3	3	4	4	4	4	4	3	3	2	2	1	1	2	4	4	4	5	5	4	4	3	3	3
4.	Dasytingis rudis Drake & Poor	*Verbinaceae* Vitex nigunda.	Nymphs feed on tender shoots and flower buds but adults feed all over the plant. Buds get charred. Damage serious.	0	0	0	0	0	0	0	0	0	0	1	2	3	3	4	4	4	3	2	2	1	0	0	0
5.	Dictyla sufflata (Drake & Poor) (wrong sym. Monanthia)	*Boraginaceae* Ehretia leavis.	Attacks tender shoots and leaves. Leaves show dark scorched paches, tender leaves crinkle and wither under high infestation. Damage serious.	0	0	0	0	0	1	3	4	9	14	10	2	1	4	6	10	10	8	4	2	0	0	0	0
6.	Monanthia globulifera Walker. (New sym. Dictyla)	*Malvaceae* Hollyhock.	... 2 .. (note in the general remarks)																								
7.	Monosteira minutula Montandon.	*Rhamnaceae* Ziziphus jujuba.	Attacks tender shoots and leaves: Buds get scorched and leaves get dechlorophylled. Damage not serious.	0	0	0	0	0	1	1	2	2	1	1	0	0	1	3	4	4	3	3	2	1	0	0	0
8.	Tingis buddleiae Drake.	*Verbinaceae* Vitex trifoliata.	Tender shoots, inflorescence and leaves are attacked. Buds and leaves get scorched, crinkled & finally wither. Damage serious.	4	4	4	4	5	6	7	7	7	3	1	1	1	1	2	3	4	5	6	8	8	5	4	4



Graph 1. Showing the population fluctuations of Tingid species of Agra during 1959 to 1960. The figures along the Y axis represent the average number of adults on a single leaf. Each month is divided into two halves.

GENERAL REMARKS

As would be evidenced by the table and the graph, out of the eleven species, *Stephanitis typicus* occurs exclusively during the winter months, *Tingis buddleiae* and *Cysteochila sp.* occur throughout the year with stray cases appearing during July and August, while the rest of the species occur exclusively during the summer months ranging from March to October. In all these cases the density of population depends on the weather conditions especially the onset of monsoon. In most cases (excluding the winter species) the peak of the population density is reached immediately after winter and soon after the monsoon. When the monsoon was delayed in 1960 a sharp decline in the population was noticed during the months of June and July. The species *Cadmilos retiarius* was found heavily infesting the host plants throughout August in 1959 but due to the late monsoon and by the attack of an Acarina ectoparasite, in 1960 the population was considerably thinned out during the end of July and disappeared in the beginning of August. *Tingis buddleiae* also showed marked ossilation; in 1959 the whole garden of *Vitex trifoliata* was infested during the end of July and stray cases appeared during August, but in 1960 the population thinned out to stray cases in the end of July and disappeared altogether in August. The genus *Urentius* is spread uniformly throughout the summer in all areas surveyed without being much affected by weather fluctuations.

Those species which attack the annuals *viz.*, *Urentius euonymus* and *Cadmilos retiarius* must have a perennial as their permanent host plant on which they overwinter. The perennials of *U. euonymus* and *Abutilon indicum*, *Sida* and *Malvestrum* whereas that of *Cadmilos retiarius* is unknown. No host plant on which more than one species of Tingids feed has been recorded. Sharga (1953) recorded *Monanthia globulifera* Walk. on *Ocimum spp.* throughout the year in the whole of U. P. The author could collect a couple of specimens from a leaf of Hollyhocks in March 1959 and further search on *Ocimum* and other plants during succeeding months in Agra produced negative results. In August 1960 this species was found heavily infesting *Ocimum spp.* in Panjab but not in Agra. In the middle of September 1960 stray cases of *Monanthia globulifera* were found in Agra on isolated plants of the whole garden of *Ocimum basilicum*. Rapid spreading on adjoining plants of the species took place during the end of September. *Ocimum basilicum* and *Ocimum gratissimum* were preferred to *Ocimum sanctum* as the host plants. Damage is very serious resulting to the curling and charring of buds and leaves. *Urentius echinus* prefers *Solanum melangina* without spines to that with spines in the same garden, but when the former is fully infested it spreads on the latter.

Though the Tingids show marked specificity to host plants, starved individuals, both adults and immature stages, when provided with leaves of other plants were found feeding on them though not indefinitely. Those species which have diverse host plants exhibit a marked preference to plants belonging to the same family. But *Cadmilos retiarius* which always attacks compositae, during the peak of the population (in August) also infests *Argemone mexicana*. This insect could be harnessed to control *Argemone* which runs wild in all parts of India. Further, forced feeding on varied food plants may produce varied strains of these insects which could be used as control over wild plants. Concentrated work on the feeding habits of these species is needed to work out the control measures.

RECORD OF A SPECIES NEW TO INDIA

The genus *Monisteira* with five recorded species is confined to the palearctic region with the exception of *Monosteira minutula* Montandon, which with a very limited distribution in Agra is being recorded here for the first time from the Indian faunal limits. It is also known from Ethiopian region. The host plant is *Ziziphus jujuba* (Ber), the detailed notes on the biology and immature stages will be published elsewhere.

DISTRIBUTION OF *Teleonemia scrupulosa* STOL

In 1941 the Forest Research Institute, Dehradun introduced this *Lantana bug*, imported from Australia to control the wild *Lantana* shrub in India. From the insectary a few insects escaped and established on Teak plantation and started spreading to the neighbouring districts creating problems for the F. R. I. In 1953 Roonwal conducted a survey throughout India to determine the rate of distribution (spreading rate) of the bug and calculated it to be 2½ miles a year. In Agra the survey was conducted by Mani and reported the absence of this species in this region (Roonwal 1953). A thorough search on all Lantana hedges and other trees in and around Agra made by the author during 1958-60 also gave negative result.

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SUMMARY

Eleven species belonging to ten genera of Tingids have been recorded in Agra with particular reference to their periodicity, and the nature of damage caused to the host plant. *Monosteira minutula* Montandon is recorded

for the first time from the Indian faunal limits. *Teleoneima scrupulosa* Stal has not spread into the Agra region.

REFERENCES

1. Distant, W. L. 1903. *The Fauna of British India,* including Ceylon and Burma. Rhynchota. **2** (1) (Heteroptera) : 120-145.
2. Distant, M. L. 1910. *The Fauna of British India,* including Ceylon and Burma. Rhynchota, **5** (Heteroptera: Appendix) : 100-126.
3. Drake, C. J. 1936. An undescribed Tingid from S. India. *J. Bombay Nat. Hist. Soc.,* **39** (1) : 145.
4. Drake, C. J. and F. A. Ruhoff. 1960. Lace-Bug genera of the world (Hemiptera: Tingidae). *Proc. U. S. Nat. Muse.,* **112** (3431) : 1-105.
5. Ghulamullah. 1941. Aphidae and some other Rhynchota from Afghanistan. *Indian J. Ent.,* **3** (2) : 225-243.
6. Khan, A. H. 1945. On the Lantana Bug (*Teleonemia scrupulosa* Stal). *Indian J. Ent.,* **6** (1-2) : 149-161.
7. Kirkaldy, G. W. 1902. Memoirs on Oriental Rhynchota. *J. Bombay Nat. Hist. Soc.,* **14** : 297-299.
8. Noel, K. L. H. 1952. Notes on the insects associated with Lantana in Cuba. *Hawaiian Ent. Soc.,* **15** (1) : 123.
9. Menon, M. G. R. and A. Hakk. 1959. Some Tingids of economic importance from Delhi State. *Proc. 46th Ind. Sci. Cong.,* Part 3, : 392.
10. Patel, R. C. and H. L. Kulkarney. 1955. Biononics of *Urentius echinus Dist.* (Hemiptera : Tingidae) an important pest of Brinjal (Solanum melongena) in North Gujarat. *J. Bom. Nat. Hist. Soc.,* **53** (1) : 86-96.
11. Roonwal, M. L. 1952. The natural establishment and dispersal of an imported insect in India—the Lantana bug *Teleonemia scrupulosa* Stal (Lantanae Dist. Hemiptera : Tingidae) with description of the egg, nymphs and adult. *Jour. Zool. Soc. India,* **4** (1) : 1-16.
12. Roonwal, M. L. 1953. Further remarks on the distribution of the Lantana bug *Teleonemia scrupulosa* Stal, in India since its introduction in 1941 from Australia. *Indian Forester,* **79** (11) : 628-629.
13. Sharga, U. S. 1953. Bionomics of *Monanthia globulifera Walk* (Hemiptera : Tingidae). *J. Bom. Nat. Hist. Soc.,* **51** (4) : 885-889.
14. Sinha, S. S. 1951. Some observations on an attack of *Urentius echinus* Dist. on Brinjal at Sabar farm *Indian J. Ent.,* **13** (2) : 182.
15. Weber, P. W. 1953. Recent liberation of beneficial insects in Hawai Part 2. *Hawaiian Ent. Soc.,* **15** (1) : 127.

FLORA OF HASTINAPUR*

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INTRODUCTION

A large number of new plants have been described and many nomenclatorial changes have also been introduced since the time of the publication of Hooker's Flora of British India. These emphasize the necessity and desirability of a revision of the flora of this country. To achieve this object with the minimum of expenditure Santapau, the then chief botanist in his presidential address before the members of the Indian Botanical Society in 1956 suggested "..............that as far as possible universities concentrate their botanical researches in their own districts and leave far away explorations to the Botanical Survey of India".

Work on the collection of plants of Meerut started in thirties when the teaching of Botany was introduced in the college. In 1953 when Government of Uttar Pradesh started work on the colonization scheme of Hastinapur it was suggested by Professor V. Puri that Hastinapur should be taken first for a more intensive study as the luxuriant vegetation of this place is likely to suffer much through human influence. It was feared that after some years the physiognomy of the whole area may totally change and, therefore, the problem appeared to be more urgent. With this view in mind Mr. Chittranjan Bhatia was asked to work out the flora of Hastinapur during 1954-55. During the short span of nine months he could only visit seven out of the fifteen blocks demarcated by the Forest Department. Even the seven blocks which are nearest to central town of Hastinapur could not be visited as often as necessary and could not be worked out in complete thoroughness due to paucity of time and finances.

The Scientific Research Committee, Uttar Pradesh was then approached for some financial assistance, which was readily granted in 1957 enabling us to make the present study.

TOPOGRAPHY AND SOIL

Hastinapur, the ancient historic capital of Kauravas and Pandavas is situated near river Ganges, 36.4 kilometers north-east of Meerut in Meerut district. It lies at 29° 1′ N latitude and 77° 9′ E longitude, and has an elevation of 215 meters above sea level.

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* Research contribution No. 35 from the School of Plant Morphology, Meerut College, Meerut.

The area includes a high level land, the 'Khola', taken up for afforestation by the Forest Department of the Uttar Pradesh Government, and a low lying land of 'Khadar', the old bed of river Ganges which has now shifted towards east, most of which is under cultivation. The 'Khola' is stretching parallel to river Ganges in a belt of over 36.4 kilometers varying in width from 0.4 to 1.6 kilometers. In the 'Khola' there are many small hillocks rising 60-90 meters form the base, and broad valley like depressions which go down 15-20 meters form the normal level. At the juction of 'Khola' and 'Khadar' there lies a discontinuous belt of highly marshy land with profuse growth of *Typha* and some tall grasses like *Phragmites* and *Arundo*. (Map).

Several temporary ravines flow across the 'Khola' during the rains. Water descends through them into 'Khadar' and ultimately meets the river Ganges. Besides, there lies a more or less permanent ravine, the Boodhi-Ganga about 0.4 kilometer from 'Khola'. It is an old branch of river Ganges which flows parallel to it for some distance and eventually merges into it. In rainy season the Boodhi-Ganga floods the neighbouring low lying area of 'Khadar', but in other seasons the movement of water in this ravine is very insignificant. In addition to it, there are several ponds and ditches in 'Khadar' with rich growth of aquatic plants.

The water table is 4 to 13 meters in 'Khola' but it is very low in 'Khadar'. There is a great diversity in the nature of soil in 'Khola'. It varies from sandy to clayey loam, while the soil of 'Khadar' is black alluvial which retains moisture to a great extent.

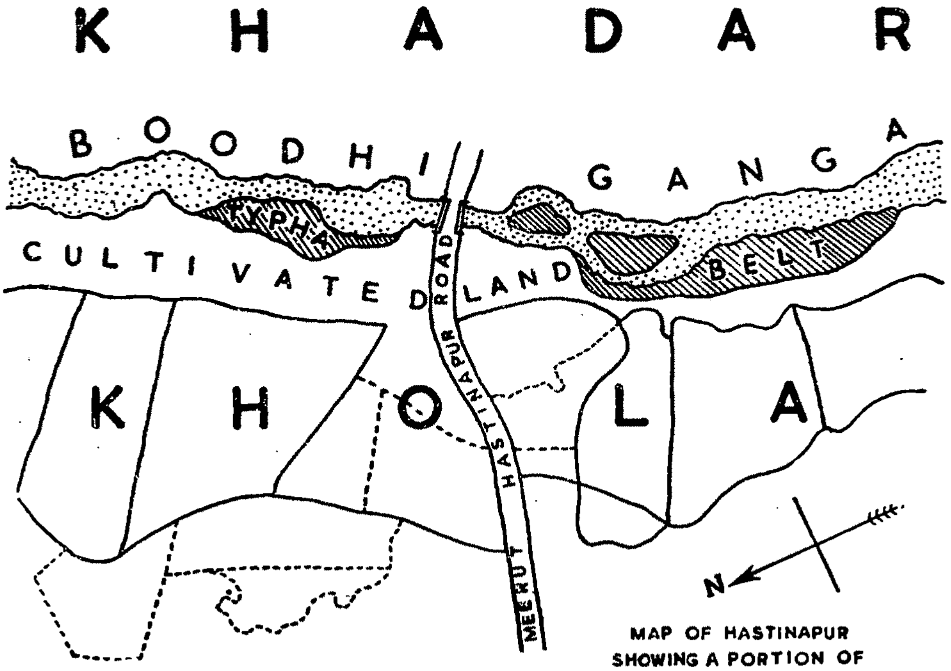
CLIMATE

The average rainfall of Hastinapur is 7,500 to 8,750 mm. (30 to 35 inches) 85% of which takes place during July to September. The winter rains are very scanty. October to February are cold months and the minimum temperature falls down to 2°C in cold frosty nights of January. Summer runs from March to June and the maximum temperature rises up to 45°C in hot noons of June. Chills in the winter dawns and hot winds in summer noons are common. On the whole climate is arid.

The vegetation is at its zenith during the rainy season, because of high humidity and moderate temperature, both favourable for plant growth. In summers, due to high temperature and low humidity the vegetation is very poor, and most of the herbaceous plants disappear.

VEGETATION

'Khola' which is now under protection of the Forest Department gives the appearance of a scrub jungle. It seems, that in the past there existed a thick forest but it has been destroyed by the inhabitants of surrounding villages who solely depend upon these forests for their timber and fuel requirements.



MAP OF HASTINAPUR
SHOWING A PORTION OF
SOODHI GANGA, TYPHA BELT
KHOLA 4 KHADAR

Grazing and browsing by cattle also led to the destruction of the natural vegetation.

As a whole the vegetation shows Xerophytic features due to arid climatic conditions. Tall trees are rare, the bushy growth is successful and occupies a greater area. The following trees are common : *Acacia nilotica, Albizzia odoratissima, Dalbergia sissoo, Diospyros cordifolia, Phoenix sylvestris, Sapium sebiferum, Streblus asper* and *Wrightia tomentosa.* Bushy growth of the following species is abundant : *Acacia concinna, Adhatoda vesica, Butea monosperma, Carissa spinarum, Casearia tomentosa, Capparis sepiaria, Flacourtia indica, Nyctanthes arbor-tristis*, etc. In marshy places *Salix tetrasperma* is also common.

Typha elephantina occurs in great abundance throughout the marshy belt. There is a rich growth of aquatic plants in Boodhi-Ganga, ponds and ditches. The following species are more common : *Ceratophyllum demersum, Hydrilla verticillata, Hygrorhyza aristata, Jussieua repens, Limnanthemum cristatum, Nymphaea lotus, Potamogeton crispus, Utricularia stellaris*, etc.

OBSERVATIONS

The present study on the Flora of Hastinapur was undertaken in June 1958. Excursions were made at intervals of 1-2 months for two continuous years. Plants collected were identified with the help of available floras, and finally they were compared with specimens in the Herbarium of the Forest Research Institute, Dehradun. The sequence of families and genera is the same adopted by Duthie in the Flora of the Upper Gangetic Plain, with some modifications. For each plant habitat, points of interest, flowering time, local name where in use, and field number are given. An attempt has been made to bring the nomenclature up to date, only important synonyms are given. Plants marked with an asterisk* have not been recorded in Duthie's flora and Raizada's list of the grasses of the Upper Gangetic Plain. Those marked with +have recently been reported by the present authors (Murty & Singh 1961 a).

TAXONOMIC DATA

RANUNCULACEAE

Ranunculus aquatilis Linn.

Frequent in ditches. Flowers white. Fl. Nov.-Jan. Murty & Singh 722.

Ranunculus sceleratus Linn.

Common in marshy and wet places. Flowers yellow. Fl. Jan.-March. Murty & Singh 546.

ANONACEAE

Anona squamosa Linn. Hindi Sharifa.

Cultivated for its edible fruits. Fl. March-May. Murty & Singh 761.

Polyalthia longifolia Benth. Hindi Ashoki.

This handsome evergreen tree is cultivated in gardens. Fl. May-June. Murty & Singh 755.

MENISPERMACEAE

Tinospora cordifolia Miers. Hindi Gloe.

Fl. March-April. Murty & Singh 718.

Cocculus hirsutus (Linn) Diels.=*Cocculus villosus* DC. Hindi Hier. Fl. Nov.-March. Murty & Singh 521.

Cissampelos pareira Linn. Hindi Purhe.

Common among the hedges. Fl. July-Oct. Murty & Singh, 45 (male) 68 (female).

NYMPHAEACEAE

Nymphaea lotus Linn. Hindi Kamal.

Common in Boodhi Ganga and in some ditches. Flowers white or pink. Fl. July-Sept. Murty & Singh 412.

Nymphaea stellata Willd. Hindi Bhambheer.

Found along with *N. lotus* but not so common. Fl. July-Sept. Murty & Singh 659.

PAPAVERACEAE

Argemone mexicana Linn. Hindi Peeli Kateli.

Very common in waste land. Fl. almost throughout the year. Murty & Singh 222.

Fumaria indica Pugsly.=*Fumaria parviflora* W. & A. non Lamk. Hindi Jangali Kalsi.

A weed of cultivated fields. Flowers pink. Fl. Dec.-March. Murty & Singh 560.

CRUCIFERAE

Rorippa montana Small.=*Nasturtium montanum* Wall.

Erect herb with yellow flowers, seeds in 2 rows. Fl. Oct.-March. Murty & Singh 606, 657.

Cardamine impatiens Linn.

Found in cultivated land; not common. Flowers white, seeds in 1 row. Fl. Aug.-Oct. Murty & Singh 658.

Sisymbrium thalianum J. Gray.

Frequent in the area. Flowers white. Fl. Cold season. Murty & Singh 532.

Brassica campestris Linn. var. *sarson* prain. Hindi Sarson.

Cultivated in cold season and also met with as an escape. Murty & Singh 649.

Brassica napus Linn. Hindi Kali Sarson.

Cultivated in cold season. Murty & Singh Feb. 59.

Eruca sativa Mill.

Cultivated in winters. Murty & Singh Jan. 59.

Coronopus didymus (Linn.) Sm. =*Senebiera didyma* pers. =*Senebiera pinnatifida* DC.

A common weed of cultivated land. Fl. Jan.-March. Murty & Singh 628.

Raphanus sativus Linn. Hindi Muli.

Cultivated for its edible roots and pods. Fl. Jan.-March. Murty & Singh Feb. 59.

CAPPARIDACEAE

Cleome viscosa Linn. Hindi Hulhul.

Common on hillocks and in cultivated land. Flowers yellow. Fl. July-Sept. Murty & Singh 109.

Gynandropsis gynandra (Linn.) Briq. =*Gynandropsis pentaphylla* DC. Hindi Hulhul.

A common weed with white flowers. Fl. July-Oct. Murty & Singh 410.

Maerua arenaria Hk. F. & Th. var. *Scabra.*

A few plants have been observed in forest area. Flowers white. Fl. July-Sept. Murty & Singh 251.

Crataeva nurvale Buch. Ham. var. *unilocularis* Jacobs. =*Crataeva religiosa* Forst. Hindi Barna.

Few young plants, probably self sown. Murty & Singh May 1960.

Capparis sepiaria Linn. Hindi Hins.

Spinous shrub common in dry situations. Fl. May-June. Murty & Singh 780.

**Capparis sepiaria* Linn. var. *retusella* HK. f. & Thoms.

Frequently found mixed with species proper. Leaves ovate lanceolate. Fl. May-June. Murty & Singh 660.

Capparis zeylanica Linn. non HK. f. & Th. =*Capparis horrida* Linn. Hindi His.

Found climbing on trees and bushes; common. Fl. Feb.-March. Murty & Singh 612.

VIOLACEAE

Hybanthus enneaspermus (Linn.) F. V. Muell. =*Ionidium heterophyllum* Vent. Hindi Ratanpurus.

Herb with solitary pink flowers. Restricted to a small locality in forest area. Fl. Sept.-Oct. Murty & Singh 290.

FLACOURTIACEAE

Flacourtia indica (Burm. f.) Merr. var. *occidentalis*. =*Flacourtia ramontchi* L'Herit. Hindi Kango.

A tall thorny shrub with yellowish green flowers; common. Fl. Feb.-March. Murty & Singh 644 (male); 646 (female).

POLYGALACEAE

Polygala erioptera DC.

Small herb with pink flowers. Common on hillocks. Fl. Aug.-Dec. Murty & Singh 176, 233.

Polygala chinensis Linn.

Frequently found in Khola during rainy season. Fl. Aug.-Nov. Murty & Singh 143.

Polygala sp.

A small herb with narrow leaves and yellow flowers. Only two plants were collected during rainy season. Murty & Singh 133.

CARYOPHYLLACEAE

Saponaria vaccaria Linn.

Commonly found in wheat fields. Flowers pink. Fl. Feb.-March. Murty & Singh 596.

Stellaria media Cyrill.

A common weed, growing luxuriantly in damp places. Petals white and bifid. Fl. Feb.-April. Murty & Singh 629.

Arenaria serpyllifolia Linn.

A weed with white flowers. Fl. Feb.-April. Murty & Singh 607.

Spergula arvensis Linn.

A common weed. Fl. Cold season. Murty & Singh 607.

Polycarpaea corymbosa Lamk.

Common in sandy places. Flowers silvery white. Fl. Aug.-Dec. Murty & Singh 236.

PORTULACACEAE

Portulaca oleracea Linn. Hindi Kulfa.

Common in moist places. Flowers bright yellow. Fl. most part of the year. Murty & Singh 354.

Portulaca quadrifida Linn.

Frequent in open places. Fl. most part of the year. Murty & Singh 408.

†**Portulaca narvula* Gray. = *Portulaca pilosa* Linn.

An annual herb with solitary, pink flowers. Fl. July-Sept. Murty & Singh 154.

TAMARICACEAE

**Tamarix troupii* Hole. = *Tamarix gallica* auct. non Linn. Hindi Jhau.

T. gallica Linn. described in the flora of Upper Gangetic Plain does not occur in India and the available species is *T. troupii* (Raizada, 1939). Occasionally found in Khadar area. Fl. July-Aug. Murty & Singh 685.

Tamarix dioica Roxb. Hindi Lal Jhau.

Frequent in Khadar. Fl. May-July. Murty & Singh 372.

MALVACEAE

Malva verticillata Linn.

Erect herb, common in waste land. Fl. Feb.-April. Murty & Singh 583, A.

Malva parviflora Linn.

A prostrate herb. Common on damp humus soil. Fl. Feb.-April. Murty & Singh 583.

Malvastrum coromandelianum Garcke. = *Malvastrum tricuspidatum* A. Gray.

A common weed. Fl. most part of the year but more vigrous from July to Sept. Murty & Singh 103.

Sida veronicaefolia Lamk.

Common throughout the area. Procombent or suberect and much hairy. Fl. Sept.-Nov. Murty & Singh 81, 107.

Sida spinosa Linn.

Erect herb with two small processes at the base of leaf. Frequent. Fl. Sept.-Nov. Murty & Singh 307.

Sida acuta Burm. f. = *Sida carpinifolia* Linn. f.

Common in waste land. Fl. Sept.-Dec. Murty & Singh 456.

Sida rhombifolia Linn.

Fairly common in waste land. Fl. Aug.-Oct. Murty & Singh. 149, 680.

Sida grewioides Guilli & Perr.

A woody herb with white or yellowish white flowers. Frequent. Fl. Aug.-Sept. Murty & Singh 316, 690.

Sida cordifolia. Linn.

Common throughout the area. Fl. Aug.-Nov. Murty & Singh. 149, 680.

Abutilon indicum Sweet Hindi Kanghi.

Common in the area particularly on waste grounds. Fl. July-Oct. Murty & Singh 681.

Abutilon ramosum Gull. & Perr.

Frequent. Fl. July-Sept. Murty & Singh 117, 185.

**Abutilon hirtum* G. Don. Hindi Barkanghi.

Shrub with showy orange flowers with a purple spot in the centre. Abundant on the slope of hillock near excavations. Fl. Oct.-Nov. Murty & Singh 446, 448.

Urena lobata Linn. Hindi Bachita.

Undershrub with pink flowers; common in forest area. Fl. Aug.-Dec Murty & Singh 218.

Urena repranda Roxb.

Similar to *U. lobata* except for smooth carpels; not so common. Fl. Aug.-Oct. Murty & Singh 219.

Hibiscus micranthus Linn.

Frequent in dry rocky places. Fl. Aug.-Sept. Murty & Singh 110, 239.

Hibiscus lobatus (Murr.) O. Ktze.=*Hibiscus solandra* L'Herit.

Annual herb with white flowers. Common. Fl. Aug.-Oct. Murty & Singh 29, 191, 205.

Hibiscus vitifolius Linn. Hindi Ban-Kapas.

Tall herb with large, yellow, drooping flowers. Common. Fl. Aug.-Oct. Murty & Singh 44.

Hibiscus cannabinus Linn. Hindi Patsan.

Frequently cultivated for its fibres. Fl. Oct. Murty & Singh 396.

Hibiscus rosa-sinensis Linn. Hindi Gudhal.

Cultivated in gardens. Murty & Singh Sept. 1958.

Abelmoschus esculentus (Linn.) Moench.=*Hibiscus esculentus* Linn. Hindi Bhindi.

Cultivated. Fruits are used as vegetables. Murty & Singh June 1959.

Gossypium arboreum Linn.=*Gossypium neglectum* Todaro. Hindi Kapas, Bari.

Largely cultivated in the area. Murty & Singh Sept. 1958.

Kydia calycina Roxb. Hindi Pula.

A small tree recently introduced by Forest Department. -Fl. Oct.-Nov. Murty & Singh 469.

BOMBACACEAE

Salmalia malabarica (DC.) Schott & Endl. =*Bombax malabaricum* DC. Hindi Semal.

Not uncommon in forest area. Fl. Feb.-March. Murty & Singh Feb. 1959.

STERCULIACEAE

Helicteres isora Linn. Hindi Marorphal.

A shrub with red flowers and characteristic fruit; very common. Fl. June-Nov. Murty & Singh 257.

Melochia corchorifolia Linn.

A weed of cultivated fields and waste land. Fl. July-Sept. Murty & Singh 201.

Waltheria indica Linn.

Undershrub with white or pink flowers. Not common. Fl. July-sept. Murty & Singh 225.

TILIACEAE

Grewia asiatica Linn. Hindi Phalsa.

Cultivated for edible fruits. Fl. Feb.-March. Murty & Singh 385.

Grewia sapida Roxb.

Frequent in the area. Fl. April-May. Murty & Singh 739.

Grewia hirsuta Vahl.

Very common in forest area. Fl. July-Sept. Murty & Singh 167.

Triumfetta bartramia Linn. = *Triumfetta rhomboidea* Jacq.

Very common throughout the area. Fl. Sept.-Nov. Murty & Singh 300.

Corchorus capsularis Linn. Hindi Harrawa.

Wild and also cultivated at some places for its fibres. Fl. July-Sept. Murty & Singh 782.

Corchorus olitorius Linn.

Very common. Fl. July-Sept. Murty & Singh 288.

Corchorus trilocularis Linn.

Occasionally met with in the area. Fl. Aug.-Sept. Murty & Singh 317.

Corchorus tridens Linn.

Frequent in the area. Fl. Aug.-Sept. Murty & Singh 395.

Corchorus aestuans Linn. non Forsk. =*Corchorus acutangulus* Lamk.

Fl. Aug.-Nov. Murty & Singh 286.

LINACEAE

Linum usitatissimum Linn. Hindi Alsi.

Cultivated for its seeds from which oil is extracted Fl. cold season. Murty & Singh Feb. 1949.

ZYGOPHYLLACEAE

Tribulus terrestris Linn. Hindi Gokhru.

Very common in dry sandy places. Fl. July-Sept. Murty & Singh 4.

Fagonia cretica Linn. =*Fagonia arabica* Linn. Hindi Jowasa.

Found in drier places. Fl. most part of the year Murty & Singh 480.

OXALIDACEAE

Oxalis corniculata Linn. Hindi Khatibuti.

Spreading herb with yellow flowers. Very common. Fl. rainy season (less vigroulsy throughout the year). Murty & Singh 79.

**Oxalis latifolia* H. B. & K.

An introduced weed with pink flowers. Reported by Raizada from the Upper Gangetic Plain. Frequent in moist shady places. Fl. June-July. Murty & Singh 778.

Averrhoa carambola Linn. Hindi Kamrakh.

Planted near the temple, fruit edible. Fl. Aug.-Sept. Murty & Singh 352.

RUTACEAE

Murraya paniculata (Linn.) Jack.=*Murraya exotica* Linn. Hindi Kamini.
Planted in gardens for its fragrant flowers. Fl. April-July. Murty & Singh June 1959.

Murraya koenigii Spreng. Hindi Mitha Neem.
Common in the area. Fl. March-April. Murty & Singh 579.

Citrus medica Linn. Hindi Nembu.
Grown in gardens for its fruits. Murty & Singh July 1959.

Citrus aurantium Linn. Hindi Narangi.
Cultivated in gardens. Murty & Singh July 1959.

Citrus maxima (Burm.) Merrill. *Citrus decumena* Linn. Hindi Chakotra.
Cultivated for its fruits. Murty & Singh July 1959.

Feronia limonia (Linn.) Swing.=*Feronia elephantum* Correa. Hindi Kaith.
Cultivated near villages. Fl. April-May. Murty & Singh 740.

Aegle marmelos Correa. Hindi Bel.
Cultivated for its fruits. Fl. May-June. Murty & Singh 741.

SIMARUBACEAE

Ailanthus excelsa Roxb. Hindi Arru.
A large tree recently introduced by forest Department. Fl. March-April. Murty & Singh 627.

MELIACEAE

Azadirachta indica Juss.=*Melia azadirachta* Linn. Hindi Neem.
Planted or self sown; common in the area. Fl. March-May. Murty & Singh 744.

Melia azedarach Linn. Hindi Bakain.
Planted at many places. Fl. March-May. Murty & Singh 743.

Toona ciliata Roem.=*Cedrela toona* Roxb. Hindi Tun.
Planted by Forest Department. Fl. March-May. Murty & Singh 742.

RHAMNACEAE

Zizyphus mauratiana Lamk.=*Zizyphus jujuba* Lamk. non Mill. Hindi Ber.
Fl. June-Oct. Murty & Singh 322, 682.

Zizyphus nummularia (Burm. f.) W. & A.=*Zizyphus rotundifolia* Lamk. Hindi Jharberi.
Very common in sandy places particularly on forest roads. Fl. Oct.-Dec. Murty & Singh 322A.

Zizyphus oenoplia Mill.
A straggling thorny shrub. Common throughout the area particularly in dry sandy places. Fl. Aug.-Oct. Murty & Singh 10.

AMPELIDACEAE

Ampelocissus latifolia (Roxb.) Planch. = *Vitis latifolia* Roxb. Hindi Panibel.

A climber with large orbicular cordate leaves. Common in forest area. Fl. June-July. Murty & Singh 262.

Cayratia carnosa Gagnep. = *Vitis carnosa* Wall = *Vitis trifolia* Linn. Hindi Amalbel.

A climber with 3-foliate leaves. Fl. June-Sept. Murty & Singh 40.

SAPINDACEAE

Cardiospermum halicacabum Linn. Hindi Kanphuta.

Common; found along the hedges. Fruits are typical, winged at the angles. Fl. July-Oct. Murty & Singh 624.

Dodonaea viscosa Jacq. Hindi Vilayti mehndi.

Cultivated as a hedge plant and also found wild in forest area. Fl. Nov.-Feb. Murty & Singh 624.

Litchi chinensis Sonner. = *Nephelium litchi* Camb. Hindi Litchi.

An evergreen tree planted for its fruits. Fl. Feb.-March. Murty & Singh 623.

ANACARDIACEAE

Mangifera indica Linn. Hindi Am.

Cultivated for its delicious fruits. Fl. Feb.-March. Murty & Singh 618.

MORINGACEAE

Moringa oleifera Lamk. = *Moringa pterygosperma* Gaertn. Hindi Sanjna.

A small tree with white scented flowers; cultivated. Fl. Feb.-April. Murty & Singh 635.

PAPILIONACEAE

Crotalaria alata Buch.-Ham.

Erect herb with decurrent stipules and yellow flowers. Frequent. Fl. April-Oct. Murty & Singh 170.

Crotalaria calycina Schrank.

Frequent. Flowers pale yellow, pods included. Fl. June-Sept. Murty & Singh 202.

Crotalaria mysorensis Roth.

Flower yellow, pods exerted. Frequent. Fl. July-Sept. Murty & Singh 206.

Crotalaria juncea Linn. Hindi Sani.

Cultivated as well as apparently wild. Fl. Aug.-Dec. Murty & Singh 341.

Crotalaria medicaginea Lamk. Var. *neglecta* Baker.

Stems ascending, racemes few flowered. Flowers yellow with purple veins. Fl. July-Oct. Murty & Singh 195, 433, 426, 567.

Crotalaria medicaginea Lamk. var. *luxurians* Baker.

A more erect, and robust plant than var. *neglecta*, racemes many flowered, flowers small. Very common throughout the area. Number of flowers is more in a raceme of rainy seasonspecimen than of winter season specimen. Fl. rainy season and cold season. Murty & Singh 7, 171, 702.

Melilotus indica All.

A common weed of cultivated land. Flowers yellow. Fl. Jan.-March. Murty & Singh 588.

Melilotus alba Desr.

A common weed with white flowers. Fl. Jan.-March. Murty & Singh 589.

Trigonella foenum-graceum Linn. Hindi Methi.

Cultivated and also met with as an escape. Fl. Jan.-Mar. Murty & Singh 716 A.

Trigonella polycerata Linn. Hindi Chini.

Common in cultivated ground. Fl. Jan.-Mar. Murty & Singh 716 B.

Trigonella corniculata Linn.

Fl. Jan.-Mar. Murty & Singh 716.

Medicago lupulina Linn.

A common weed with unarmed one seeded pods. Fl. Jan.-Mar. Murty & Singh 597.

Medicago denticulata Willd.

Pods spiral, muricate, many seeded; common in cultivated lands. Fl. Jan.-March. Murty & Singh 594.

Medicago sativa Linn. Hindi Rijka.

Cultivated in winter season used as fodder for horses. Fl. cold season. Murty & Singh Feb. 1959.

Atylosia scarabioides Benth.

Common; twining on tall herbs. Fl. July-Sept. Murty & Singh 301, 314.

Atylosia platycarpa Benth.

Frequent in the area. Fl. July-Sept. Murty & Singh 311.

Cajanus cajan (Linn.) Millsp.=*Cajanus indicus* Spreng. Hindi Arhar.

Cultivated throughout the area. Murty & Singh 476.

Rhynchosia aurea DC. var. *capitata*=*Rhynchosia capitata* DC.

This trailing herb is frequent in the area. Fl. Aug.-Oct. Murty & Singh 266.

†**Rhynchosia minima* DC. var. *laxiflora* Baker.

Very common in the forest area twining on adjacent plants. Fl. Aug.-Sept. Murty & Singh 282, 688.

Rhynchosia sericea Spanoghe

Frequent; climbing on bushes. Fl. Aug.-Oct. Murty & Singh 295.

Phaseolus aconitifolius Jacq. Hindi Moth.

Cultivated and also commonly found as an escape. Fl. Sept.-Oct. Murty & Singh 415.

Phaseolus radiatus Linn. Hindi Mung.

Commonly cultivated. Fl. Sept.-Oct. Murty & Singh 315.

Phaseolus auriens Roxb. =*Phaseolus Mungo* Linn. Hindi Urd.

Largely cultivated in rainy season. Fl. Sept-Nov. Murty & Singh 441.

Phaseolus sublobatus Roxb. Hindi Jangli Mung

Frequent; wild in the forest area. Fl. Sept.-Oct. Murty & Singh 162.

Vigna sinensis (Linn.) Sari. =*Vigna catiang* Walp. Hindi Lobhia.

Cultivated for its pods. Fl. Sept.-Nov. Murty & Singh 394 A.

Dolichos lablab Linn. Hindi Sem

Commonly cultivated. Fl. Oct.-Dec. Murty & Singh 394.

Dolichos biflorus Linn. Hindi Kulat.

Growing wild in the open forest; very common. Fl. Sept.-Nov. Murty & Singh 689.

Clitoria ternatea Linn.

Fl. July-Sept. Murty & Singh 783.

Mucuna pruriens DC. Hindi Kaunch.

This annual climber with purple flowers is frequent in dry places in forest area. Fl. late Sept.-Nov. Murty & Singh 330.

Erythrina suberosa Roxb. Hindi. Dauldhak.

A small prickly tree, occasionally found. Fl. March-April. Murty & Singh 724.

Butea monosperma (Lamk.) Taub. =*Butea frondosa* Koening ex Roxb. Hindi Dhak.

This small tree with bright orange red flowers is fairly common in forest growing more successfully on clayey soil. Fl. March-April. Murty & Singh 570.

Sesbania sesban (Linn.) Merr. var. *typica* Prain. =*Sesbania aegyptiaca* Poir. Hindi Jait.

Planted at the edges of fields and also wild in waste land. Flowers yellow. Fl. chiefly in cold season, also flowers in other seasons. Murty & Singh 485.

Sesbania sesban (Linn.) Merr. var. *bicolor* W. & A.

Corolla yellow, standard purple from outside. Fl. cold season. Murty & Singh 454.

Sesbania bispinosa (Jacq.) W. F. Wight. =*Sesbania aculeata* Pers.

Frequent in rice fields and marshy places. Flowers yellow. Fl. Aug.-Oct. Murty & Singh 425.

Tephrosia tenuis Wall.

A small grass like herb; common on hillocks. Fl. Aug.-Sept. Murty & Singh 177.

Tephrosia purpurea Pers. = *Tephrosia procombens* Linn.

Common in sandy localities. Fl. Aug.-Nov. Murty & Singh 37, 168, 189, 340.

Tephrosia pumila Pers. = *Tephrosia purpurea* var. *pumila*

Common. Fl. Aug.-Nov. Murty & Singh 119, 274.

Cymopsis tetragonolobus (Linn.) Taub. = *Cymopsis psoralioides* DC. Hindi Guar.

Cultivated; pods are used as vegetable. Fl. Aug.-Sept. Murty & Singh Sept. 1959.

Indigofera linifolia Retz.

Prostrate herb with one seeded pods and simple leaves. Fairly common in open sandy places. Fl. Aug.-Nov. Murty & Singh 175.

Indigofera cordifolia Heyne ex Roth.

A small herb common in dry rocky places. Fl. Sept.-Oct. Murty & Singh 230.

Indigofera enneaphylla Linn.

Very common in waste land and overgrazed ground. Fl. July-Oct. Murty & Singh 27, 114.

Indigofera glabra Linn.

Frequent in open forest. Fl. Aug.-Oct. Murty & Singh 57, 242.

Indigofera hirsuta Linn.

Occasionally found in waste ground. Fl. Aug.-Oct. Murty & Singh 160.

Indigofera tinctoria Linn. Hindi Neel.

A small woody shrub frequently found wild in the area. Fl. Aug.-Sept. Murty & Singh 181.

Cicer arietinum = Linn. Hindi Chana.

Cultivated during the cold season. Fl. Jan.-Feb. Murty & Singh 647.

Lens culinare Medic. = *Lens esculenta* Moench. Hindi Masur.

Cultivated. Fl. Jan.-Feb. Murty & Singh Jan. 1959.

Vicia hirsuta S. F. Gray.

Climbing annual, pods 2 seeded. Fl. Jan.-March. Murty & Singh 593.

Vicia sativa Linn.

Common in waste places and cultivated fields. Fl. Jan.-March. Murty & Singh 590.

Vicia faba Linn. Hindi Bakla.

Cultivated. Fl. Feb.-March. Murty & Singh March 1959.

Lathyrus aphaca Linn.

Frequent in cultivated lands. Flowers yellow. Fl. Jan.-March. Murty & Singh 650.

Lathyrus sativus Linn.

Self sown. Fl. Jan.-March. Murty & Singh 633.

Pisum arvense Linn. Hindi Choti mattar.

Flowers purplish pink, seeds compressed. Largely cultivatd in winter crop. Fl. Jan.-March. Murty & Singh March 1959.

Pisum sativum Linn. Hindi Bari Mattar.

Flowers white, seeds globose. Commonly cultivated. Fl. Jan.-March Murty & Singh March 1959.

Abrus precatorius Linn. Hindi Ratti, Chauntli.

A climbing shrub with pinkish or white flowers. Common. Fl. Aug.-Sept. Murty & Singh 115.

Dalbergia latifolia Roxb. Hindi Safed Shesham.

We have seen only one tree growing near forest nursery in Karan block. Fl. March-April. Murty & Singh 781.

Dalbergia sissoo Roxb. Hindi Shisham.

A large tree, common throughout the area. Fl. March.-April. Murty & Singh 632.

Zornia diphylla Pers.

A small herb with pale yellow flowers. Common in open grassy places. Fl. July-Sept. Murty & Singh 210.

Aeschynomene indica Linn. Hindi Sola.

A tall annual with yellowish white flowers. Frequent in rice fields and other marshy and wet places. Fl. Aug.-Oct. Murty & Singh 196.

Uraria picta Desr.

Frequent in open forest particularly in dry situations. Fl. Aug.-Sept. Murty & Singh 217.

Alysicarpus monilifer DC.

A diffuse herb, pods moniliform. Common in open grassy places. Fl. Aug.-Sept. Murty & Singh 111.

Alysicarpus hamosus Edgew.

Plants hairy, pods compressed. Frequent. Fl. Aug.-Sept. Murty & Singh 386.

Alysicarpus vaginalis DC.

Fairly common. Fl. Aug.-Oct. Murty & Singh 31, 294, 381, 426.

Alysicarpus bupleurifolius DC.

Frequent in open places. Fl. Aug.-Sept. Murty & Singh 691.

Alysicarpus rugosus DC.

A variable herb, pods included in calyx. Joints of pod prominently marked with transverse lines. Fl. Aug.-Sept. Murty & Singh 484, 692.

Alhagi camelorum Fisch. Hindi Jawasa.

A thorny shrub with red flowers. Occasionally found in dry sandy places. Fl. Aug.-Sept. Murty & Singh 428.

Desmodium triflorum DC.

A traling herb common in wet places and in pastures. Fl. Aug.-Jan. Murty & Singh 353.

Desmodium gangeticum DC.

Frequently found. Fl. July.-Oct. Murty & Singh 243.

Desmodium latifolium DC.

Occasionally found in partial shady places. Fl. Aug.-Oct. Murty & Singh 243 A.

Arachis hypogea Willd. Hindi Mungfali.

Cultivated. Fl. Oct.-Nov. Murty & Singh Nov. 1959

CAESALPINIACEAE

Cassia fistula Linn. Hindi Amaltas.

A handsome tree with bright yellow flowers. Cultivated in gardens and on roadsides. Fl. May-June. Murty & Singh 735.

Cassia occidentalis Linn. Hindi Kasaunda.

A common weed of waste ground. Fl. Aug.-Oct. Murty & Singh 327.

Cassia sophera Linn. Hindi Kasaunda.

Occasionally found. Fl. Sept.-Nov. Murty & Singh 430.

Cassia obtusifolia Linn. Hindi Panwar.

A very common weed of rainy season. Fl. Aug.-Oct. Murty & Singh 106.

Cassia absus Linn. Hindi Chaksu.

An erect herb with reddish yellow flowers. Frequent in open forest growing in dense patches. Fl. Sept.-Oct. Murty & Singh 229.

Cassia pumila Lamk.

A prostrate herb with red flowers. Frequent in open sandy places. Fl. Sept.-Oct. Murty & Singh 247.

Bauhinia racemosa Lamk. Hindi Papri.

A small tree with cream-coloured floweres. Occasionally found in forest. Fl. March-May. Murty & Singh 745.

Bauhinia purpurea Linn. Hindi Kairwal.

A medium sized tree with large reddish purple flowers. Planted by Forest Department. Fl. Sept.-Nov. Murty & Singh 455.

Bauhinia variegata Linn. Hindi Kachnar.

Cultivated in gardens: Fl. Feb.-April. Murty & Singh 622.

Tamarindus indica Linn. Hindi Imli.

Fl. June-July. Murty & Singh 774.

Caesalpinia pulcherrima Swartz.

Cultivated in gardens. Fl. cold season and hot season. Murty & Singh 726.

Parkinsonia aculeata Linn. Hindi Vilayati kikar.

A spinous shrub with yellow flowers. Cultivated. Fl. Aug.-Sept. Murty & Singh 432.

Delonix regia (Boj) Raf. =*Poinciana regia* Boj ex Hook. Hindi Gulmohar. This beautiful ornamental tree is cultivated in gardens. Fl. May-June. Murty & Singh 754.

MIMOSACEAE

Prosopis juliflora DC.

This tree has been introduced by Forest Department, now running successfully in dry sandy places of Hastinapur. Fl. Aug.-Sept. Murty & Singh 332, 619.

Leucaena glauca Benth.

Only two plants were observed. Fl. most part of the year. Murty & Singh 523.

Mimosa pudica Linn.

Growing wild near temples. Fl. Aug.-Oct. Murty & Singh 431.

Acacia farnesiana Willd. Vilayati kikar.

A small tree with bright yellow, fragrant heads. Frequent in the area. Fl. Jan.-March. Murty & Singh 554.

Acacia nilotica (L) Del. =*Acacia arabica* Willd. Hindi Babul, kikar. Very common in the area, probably planted. Fl. Aug.-Nov. Murty & Singh 240.

Acacia leucophloea Willd. Hindi Safed kikar.

Heads white or cream-coloured. A few plants were observed. Fl. Sept.-Oct. Murty & Singh 554.

Acacia catechu Willd. Hindi Khair.

Commonly planted. Fl. Aug.-Sept. Murty & Singh 221.

Acacia concinna DC. Hindi Rasane.

A scrambling shrub with large, brick red heads. Fairly common in the forest. Fl. Aug.-Oct. Murty & Singh 164, 512.

† **Acacia gageana* Craib.

A prickly climber with yellowish white heads. Not common; only restricted to a small locality. Fl. Sept.-Oct. Murty & Singh 279.

Acacia auriculiformis A. cum.

Planted in gardens. Fl. Aug.-Oct. Murty & Singh 299, 636.

Albizzia lebbek Benth.

A large tree, frequently planted. Fl. April-May. Murty & Singh.746.

Albizzia odoratissima Benth. Hindi Siris.

Planted at many places. Fl. April-May. Murty & Singh. 342, 747.

Pithecolobium dulce Benth. Hindi Jungle jalebi.

Planted at some places. Fl March. Murty & Singh 748.

ROSACEAE

Prunus persica Stokes. Hindi Aru.

Cultivated in gardens. Fl. March. Murty & Singh 732.

Prunus communis Hudo. Hindi Alucha.

Cultivated in gardens. Fl. March. Murty & Singh 733.

Potentilla supina Linn.

Small herb with yellow flowers. Occasionally found in moist places. Fl. Feb.-March. Murty & Singh 727.

Rosa spp.

Many species and varieties are cultivated in gardens. Murty & Singh Dec. 1959.

Eryobotrya japonica Lindl. Hindi Loquat.

Cultivated at some places for its fruits. Fl. Sept.-Oct. Murty & Singh Sept. 1958.

CRASSULACEAE

Bryophyllum pinnatum (Lamk.) Oken. =*Bryophyllum calycinum* Salisb.

Becoming naturalised at some places. Murty & Singh 756.

COMBRETACEAE

Terminalia belerica Roxb. Hindi Bahera.

Common; planted in forest area and by road-sides. Fl. April-June. Murty & Singh 757.

Terminalia arjuna Bedd. Hindi Arjun.

Planted in the forest area. Fl. May-June. Murty & Singh 346, 738.

Quisqualis indica Linn.

A scandent shrub cultivated in gardens. Fl. June-Sept. Murty & Singh July 1959.

MYRTACEAE

Syzygium cumini (Linn.) Skeels. *Eugenia jambolana* Lamk. Hindi Jamun.

Common; wild or cultivated. Fl. April-May. Murty & Singh 753.

Psidium guajava Linn. Hindi Amrud.

Cultivated in gardens. Fl. April-May. ; Oct.-Nov. Murty & Singh 749.

Callistemon lanceolatus Sweet.

Cultivated in gardens. Fl. March-May. Murty & Singh 626.

Eucalyptus citriodora Hook.

Cultivated in gardens. Fl. March-May. Murty & Singh 628.

LYTHRACEAE

Ammania rotundifolia Buch-Ham.

Stems up to 50 cms. rooting at nodes. Flowers pink in dense terminal spikes. Common in marshy places. Fl. Feb.-March. Murty & Singh 592.

Ammania pentandra Roxb.

Erect herb with solitary axillary flowers. Rare, met with in wet places. Fl. July-Jan. Murty & Singh 489.

Ammania baccifera Linn.

Erect herb; flowers in dense axillary cymes. Very common in rice fields, wet and marshy places. Fl. rainy season and cold season. Murty & Singh 458.

Ammania salicifolia Monti.

Very similar to *A. baccifera* except for leaves; occur in the same localities but not so common. Fl. rainy season and cold season. Murty & Singh 514.

Ammania senegalensis Lamk.

Occasionally met with in moist places. Fl. July-Sept. Murty & Singh 489 A.

Lawsonia inermis Linn. =*Lawsonia alba* Lamk. Hindi Mehndi.

Often grown as hedge plant. Fl. Oct.-Nov. Murty & Singh 713.

Lagerostroemia indica Linn.

Cultivated in gardens. Fl. April-June. Murty & Singh 758.

Lagerostroemia speciosa (Linn.) Pers. =*Lagerostroemia flos-regina* Retz.

Cultivated in gardens. Flowers large, showy, pink-purple. Fl. May-June. Murty & Singh 734.

PUNICACEAE

Punica granatum Linn. Hindi Anar.

Cultivated in gardens for its fruits. Fl. most part of the year. Murty & Singh 752.

ONAGRACEAE

Jussieua repens Linn.

Fairly common in ponds. Fl. cold season. Murty & Singh 510.

Jussieua suffructicosa Linn.

Erect herb with yellow flowers. Frequent in wet places. Fl. Sept.-Dec. Murty & Singh 390.

Ludwigia parviflora Roxb.

Very common in marshy localities. Fl. Sept.-Nov. Murty & Singh 334.

Trapa bispinosa Roxb. Shinghara.

Common in jheels. Fl. August. Murty & Singh 358.

SAMYDACEAE

Casearia tomentosa Roxb.

This shrub is fairly common in forest area. Fl. March-May. Murty & Singh 543.

CARICACEAE

Carica papaya Linn. Hindi Papita.
Cultivated. Fl. most part of the year. Murty & Singh 63.

CUCURBITACEAE

Trichosanthes cucumerina Linn. Hindi Jangli chachinda.
Frequent in forest. Fl. Sept.-Nov. Murty & Singh 17, 436.

Trichosanthes anguina Linn. Hindi Chachinda
Cultivated. Fl. Aug.-Oct. Murty & Singh Sept. 1959.

Trichosanthes dioica Roxb. Hindi Palwal.
Frequent; both cultivated and wild. Fl. July-Sept. Murty & Singh 180.

Lagenaria vulgaris Ser. Hindi Lauki, Ghiya.
Cultivated. Fl. July-Dec. Murty & Singh Sept. 1959.

Luffa cylindrica (Linn.) M. V. Roem.=*Luffa aegyptiaca* Mill. Hindi Ghiya tori.
Cultivated in rainy season. Fl. July-Sept. Murty & Singh Sept. 1959.

Luffa acutangula Roxb. Hindi Kali tori.
Commonly cultivated. Fl. July-Sept. Murty & Singh 102.

Momordica charantia Linn. Hindi Karela.
Cultivated. Fl. Aug.-Oct. Murty & Singh Sept. 1959.

Momordica dioica Roxb. ex Willd. Hindi Jangli karela.
Frequent in hedges. Fl. Aug.-Sept. Murty & Singh 173.

Cucumis melo Linn. Hindi Kharbuza.
Cultivated. Fl. Feb.-March. Murty & Singh March 1959.

Cucumis melo Linn. var. *utilissimus.* Hindi Kakri.
Cultivated. Fl. Feb.-March. Murty & Singh March 1959.

Cucumis melo Linn. var. *momordica.* Hindi Kachra, Phut.
Cultivated. Fl. June-July. Murty & Singh June 1959.

Cucumis sativus Linn. Hindi Khira.
Cultivated. Fl. June-Aug. Murty & Singh June 1959

Citrullus vulgaris Schrod. Hindi Tarbuz.
Cultivated. Fl. April-June. Murty & Singh. June 1959.

Citrullus vulgaris Schrod. var. *fistulosus.* Hindi Tinda.
Cultivated. F. May-June. Murty & Singh June 1959.

Coccinia cordifolia (Linn.) Cogn.=*Coccinia indica* W. & A. Hindi Kanduri.
Common; climbing among hedges. Fl. April-Sept. Murty & Singh 261.

Cucurbita moschata Duschesne. Hindi Shitaphal, Kaddu.
Cultivated. Fl. rainy season. Murty & Singh August 1958.

Melothria perpusilla Cogn.
Frequent in the area. Fl. Sept.-Nov. Murty & Singh 281.

Melothria maderaspatana Cogn.

Common in dry sandy places. Fl. July-Sept. Murty & Singh 35.

Actinostemma tenerum Griff.

This plant which is reported by Duthie from Pilibhit and Oudh is fairly common in marshy places. Flowers small, white. Fl. Sept.-Nov. Murty & Singh 363.

CACTACEAE

Opuntia dilleni Haw. Hindi Nagphani.

Frequent on the edges of fields. Fl. April-May. Murty & Singh 751.

AIZOACEAE

Trianthema portulacastrum Linn. = *Trianthema monogyna* Linn.

Common in waste land. Fl. Aug.-Oct. Murty & Singh 368.

Trianthema triquetra Willd. ex Rottl. = *Trianthema crystallina* auct. non Vahl.

Occasionally found in dry sandy places. Fl. July-Sept. Murty & Singh 303.

Trianthema decandra Linn. = *Trianthema pentandra* Quet. non Linn.

Frequent in the area. Fl. July-Sept. Murty & Singh 33.

MOLLUGINACEAE

Glinus lotoides Linn. *Mollugo hirta* Thunb.

Frequent in Khadar after rains. Fl. Oct.-Dec. Murty & Singh 492.

Mollugo pentaphylla Linn.

Rare in the area. Fl. Oct.-Dec. Murty & Singh 715.

Gisekia pharnaceoides Linn.

Frequent in sandy places. Fl. Aug.- Nov. Murty & Singh 482.

UMBELLIFERAE

Centella asiatica (Linn.) Urban = *Hydrocotyle asiatica* Linn. Hindi Brahmi.

Frequent in wet places particularly near water edges. Fl. Nov.-Feb. Murty & Singh 661.

Anethum graveolens Linn. = *Peucedanum graveolens* Benth. & Hk. f. Hindi Sowa.

Cultivated and also met with as an escape. Fl. Jan.-March. Murty & Singh 610.

Coriandrum sativum Linn. Hindi Dhaniya.

Commonly cultivated. Fl. Jan.-March. Murty & Singh 728.

Daucas carota Linn. Hindi Gajar.

Cultivated for its edible roots. Murty & Singh Dec. 1959.

RUBIACEAE

Oldenlandia corymbosa Linn. Hindi Daman paper.

A weed common in moist places. Fl. June-Dec. Murty & Singh 82, 207

Morinda tinctoria Roxb. Hindi Al.

Small tree with white flowers. Fl. May-June. Murty & Singh 759.

Borreria stricta (Linn. f.) Schum.=*Spermacoce stricta* Linn. f.

An erect annual with white flower. Frequent throughout the area. Fl. July-Sept. Murty & Singh 24.

Borreria hispida (Linn.) Schum.=*Spermacoce hispida* Linn.

A procombent herb with liliac flowers. Very common during monsoon. Fl. July-Sept. Murty & Singh 2, 11.

COMPOSITAE

Vernonia cinerea Less.

Very common throughout the area. Fl. most part of the year. Murty & Singh 165, 326, 450, 551.

Ageratum conyzoides Linn.

Common in damp places, often a weed of cultivated fields and gardens. Fl. Jan.-March. Murty & Singh 573.

Centipeda minima (Linn.) A. Per et Aschers.=*Centipeda orbicularis* Lour.

Occasionally found in muddy places. Fl. cold season. Murty & Singh 467.

Erigeron canadensis Linn.

Frequent. Fl. July-Dec. Murty & Singh 199.

**Erigeron linifolius* Willd.

Commonly met with in the area. Fl. June-Dec. Murty & Singh 62.

Conyza aegyptiaca Dryand.

Not common. Fl. March-May. Murty & Singh 616.

Blumea lecera DC.

Very common throughout the area. Fl. Feb.-June. Murty & Singh 750.

Blumea laciniata DC.

Common in open places. Fl. March-June. Murty & Singh 599.

Pluchea tomentosa DC.

A low shrub with pinkish heads frequent in the area. Fl. Dec.-Jan. Murty & Singh 515.

Sphaeranthus indicus Linn.

Frequent in wet places and drying up rice fields. Heads magenta coloured. Fl. Feb.-March. Murty & Singh 581.

Gnaphalium indicum Linn.

A small wooly herb, frequent in damp shady places. Fl. Jan.-March. Murty & Singh 638.

Gnaphalium purpureum Linn.

This sparshly cottony herb is common throughout the area. Fl. Oct.-March. Murty & Singh 470, 634.

Caesulia axillaris Roxb.

Common in marshy places. Heads sessile axillary. Fl. Sept.-Dec. Murty & Singh 464.

Vicoa indica (Willd.) DC.=*Inula indica* Willd.

Very common. Fl. Nov.-March. Murty & Singh 447.

Vicoa vestita Benth. ex Hook. f.=*Inula vestita* Wall.

Fairly common. Plants wooly, heads yellow. Fl. March-May. Murty & Singh 595.

Pulicaria angustifolia DC.

A diffuse herb with cottony branches. Frequent in open sandy places. Fl. June-Oct. Murty & Singh 712.

Xanthium strumarium Linn.

Frequent in waste land. Fl. Oct.-Nov. Murty & Singh 457.

Siegesbeckia orientalis Linn.

Common in damp and partial shady places. Fl. Sept.-Oct. Murty & Singh 159.

Eclipta prostrata Linn.=*Eclipta alba* (Linn.) Hosk.=*Eclipta erecta* Linn.

Very common throughout the area in wet places. Fl. almo st all the year round. Murty & Singh 72.

Bidens biternata (Lour.) Merr. & Sharff.=*Bidens pilosa* Linn.

Frequent with in the area. Fl. Aug.-Oct. Murty & Singh 49.

Tridax procombens Linn.

Fairly common in waste land and by roadsides. Fl. most part of the year. Murty & Singh 6.

Cotula anthemoides Linn.

This small prostrate herb is occasionally found in wet places. Fl. Jan.-March. Murty & Singh 582.

Artemisia scoparia Waldst & Kit.

Tall herb with yellow flowers. Abundant on forest roads. Fl. Sept.-Nov. Murty & Singh 380.

Artemisia nilgrica Pampanini=*Artemisia vulgaris* Linn.

An aromatic shrub with brownish yellow heads; rare. Fl. Sept.-Nov. Murty & Singh 390 A.

**Artemisia parviflora* Roxb.

A small shrub with yellowish green heads; uncommon. Fl. Sept.-Nov. Murty & Singh 362.

Emilia sonchifolia DC.

Diffuse herb with pink heads. Frequent in cultivated land. Fl. July-Dec. Murty & Singh 161, 558.

Cnicus arvensis Hoffm.

Frequent in waste places and cultivated land. Fl. Feb.-May. Murty & Singh 291.

Saussurea candicans Clarke.

A handsome weed with large pinkish heads. Not common. Fl. March-May. Murty & Singh 564.

Volutarella ramosa (Roxb.) Santapau = *Volutarella divaricata* Benth. & Hook. f.

Straggling herb with pale purple heads. Frequent in dry sandy places. Fl. Nov.-April. Murty & Singh 577.

**Carthamus oxyacantha* Bieb.

A spinose herb with pale orange heads. Common weed of waste land. Fl. March-May. Murty & Singh 723.

Lactuca sativa Linn.

Cultivated. Murty & Singh Feb. 1959.

Sonchus oleraceus Linn.

Fairly common in cultivated land. Fl. March-Sept. Murty & Singh 452, 511.

Sonchus asper Hill.

Common weed of cultivation. Fl. Nov.-April. Murty & Singh 563.

Launaea asplenifolia Hook. f.

Frequent in the area. Fl. Nov.-March. Murty & Singh 617.

Launaea nudicaulis Hook. f.

Common in cultivated land. Fl. Oct.-March. Murty & Singh 142, 291.

CAMPANULACEAE

Campanula canescens Wall.

Erect herb with lilac or purple flowers; common. Fl. March-April. Murty & Singh 539, 557.

PLUMBAGINACEAE

Plumbago zeylanica Linn. Hindi Chitra.

A low shrub with white flowers. Frequent in forest. Fl. Sept.-Nov. Murty & Singh 304.

PRIMULACEAE

Anagallis arvensis Linn.

Small herb with bright blue flowers. Common weed of cultivated land. Fl. Jan.-March. Murty & Singh 556.

SAPOTACEAE

Manilkara hexandra (Roxb.) Dub. = *Mimusops hexandra* Roxb. Hindi Khirni.

Cultivated. Fl. Oct.-Dec. Murty & Singh 714.

Madhuca indica Gmel. = *Bassia latifolia* Roxb. Hindi Mahua.

Planted by Forest Department. Fl. March-April. Murty & Singh 784.

EBENACEAE

Diospyros cordifolia Roxb. Hindi Bisandu.

This small tree is fairly common in forest area. Fl. April-earlyMay. Murty & Singh 760 (Male); 760 A (Female).

OLEACEAE

Jasminum multiflorum (Burm. f.) Andr. =*Jasminum pubescens* Willd. Hindi Chameli.

A scandent shrub with fragrant white flowers. Frequent in forest. Fl. Sept.-Nov. Murty & Singh 278.

APOCYNACEAE

Carissa carandas Linn. Hindi Karaunda.

Wild and also cultivated as a hedge plant. Fl. Aug.-Oct. Murty & & Singh 379.

Carissa spinarum Linn. Hindi Karaundi.

A low shrub common in open forest. Fl. Aug.-Oct. Murty & Singh 379.

Lochnera pusilla (Murr.) Schum. = *Vinca pusilla* Murr.

Frequent in rich soil. Fl. July-Nov. Murty & Singh 493.

Tabernaemontana divaricata (Linn.) R. Br. =*Ervatamia coronaria* Stapf. Hindi Chandni.

Often cultivated in gardens. Fl. May-Aug. Murty & Singh 785.

Wrightia tomentosa R. Br. Hindi Dudhi.

A small tree with white flowers tinged with pink. Occasionally found in forest. Fl. May-June. Murty & Singh 343, 736.

Nerium indicum Mill. =*Nerium odorum* Soland. Hindi Kaner.

Often cultivated in gardens. Fl. most part of the year. Murty & Singh 763.

Ichnocarpus frutescens R. Br. Hindi Kali dudhi.

A rambling shrub with white flowers; very common. Fl. Aug.-Dec. Murty & Singh 260.

Thevetia peruviana (Pers.) K. Schum. = *Thevetia nerifolia* Juss. ex Steud. Hindi Peeli Kanar.

Cultivated in gardens. Fl. most part of the year. Murty & Singh 762.

Plumeria rubra Linn. forma *acutifolia* (Poir) Woodson. =*Plumeria acutifolia* Poir.

Cultivated in gardens. Fl. May-July. Murty & Singh 764.

ASCLEPIADACEAE

Calotropis procera R. Br. Hindi Ankha.

Frequent in waste land. Fl. March-Aug. Murty & Singh 3.

Oxystelma esculentum R. Br.

A twiner with pink flowers. Frequent in wet places. Fl. Sept.-Oct. Murty & Singh 370.

Pergularia daemia (Forsk.) Chiov.=*Daemia extensa* R. Br.

Occasionally found in hedges. Fl. Sept.-Nov. Murty & Singh 479.

Leptadenia reticulata W. & A.

A twiner with pale brown flowers; common. Fl. July-Oct. Murty & Singh 325.

Leptadenia pyrotechnica (Forsk.) Decne=*Leptadenia spartium* Wight.

A bush often leafless. Occasionally found in dry sandy places. Fl. Sept-Oct. Murty & Singh 404.

**Cryptostegia grandiflora* R. Br.

Frequent; flowers dull purple. Fl. June-Sept. Murty & Singh 411.

GENTIANACEAE

Enicostemma verticillatum (Linn.) Engl =*Enicostemma littorale* Blume.

Frequent in wet and partial shady places. Fl. July-Sept. Murty & Singh 494.

Limnanthemum cristatum Griseb.

A floating herb with white flowers. Very common in ponds and ditches. Fl. March-Sept. Murty & Singh 418, 603.

HYDROPHYLLACEAE

Hydrolea zeylanica Vahl.

Annual herb with blue flowers, calyx gland pubescent. Frequent in wet places. Fl. Oct.-Dec. Murty & Singh 474.

BORAGINACEAE

Cordia myxa Linn. Hindi Lasora.

Small tree with fragrant white flowers. Occasionally seen in forest. Fl. March-April. Murty & Singh 728.

Ehretia aspera Roxb.

Frequent in forest area. Fl. March-May. Murty & Singh 50, 615

Heliotropium eichwaldi Steud ex DC.

Erect herb with white flower. Frequent. Fl. Dec.-March. Murty & Singh 525

Heliotropium strigosum Willd.

This procombent herb is very common all over the area in sandy places. Fl. July-Sept. Murty & Singh 28.

Trichodesma indicum R. Br.

Very common in waste and; flowers pale blue. Fl. Aug.-Nov. Murty & Singh 1.

Cynoglossum meeboldii Brand. = *Cynoglossum denticulatum* DC. var. *Zeylanica* C. B. C.

Frequent in the area. Fl. Aug.-Oct. Murty & Singh 8.

Arnebia hispidissima DC. Hindi Ratan jyot.

Very common in dry sandy places. Flowers yellow. Fl. March-May. Murty & Singh 669.

CONVOLVULACEAE

Cuscuta reflexa Roxb. Hindi Amarbel, Akasbel.

This stem parasite is very common throughout the area on bushes and small trees. Fl. Oct.-Jan. Murty & Singh 449.

Evolvulus alsinoides Linn.

Fairly common in open sandy places. Fl. July-Nov. Murty & Singh 42.

Convolvulus pluricaulis Chois.

Very common in dry sandy places. Fl. Feb.-May. Murty & Singh 527.

Convolvulus arvensis Linn.

Common in cultivated land. Fl. Jan.-March. Murty & Singh 637.

Merremia hederacea (Burm. f.) Hall. f. = *Merremia chryseides* Hall. f.

Twining herb; frequent in wet and marshy places. Flowers yellow. Fl. Sept.-Dec. Murty & Singh 368, 683.

Ipomoea hispida (Vahl.) R. & S.

Common in sugar-cane fields. Fl. July-Sept. Murty & Singh 232.

Ipomoea sindica Stapf.

Occasionally found in the area. Fl. Sept.-Oct. Murty & Singh 495.

Ipomoea pilosa Sweet.

A hairy twiner with purple flowers. Frequent in forest. Fl. Sept.-Nov. Murty & Singh 378.

Ipomoea aquatica Forsk. = *Ipomoea reptans* Poir. Hindi Nali-ka-sag.

Common in ponds, ditches and other muddy places. Fl. most part of the year. Murty & Singh 367.

Ipomoea maxima (Linn. f.) Don ex Sweet. = *Ipomoea sepiaria* Koenig ex Roxb.

Frequent in hedges. Fl. Aug.-Oct. Murty & Singh 473.

Ipomoea obscura Ker-Gawl.

Twiner, common on forest roads, flowers white. Fl. Sept.-Nov. Murty & Singh 697.

Ipomoea nil (Linn.) Roth. = *Ipomoea hederacea* auct. non Jacq.

Common in hedges; flowers rose coloured. Fl. Aug.-Nov. Murty & Singh 116.

Ipomoea pestigridis Linn.

Abundant throughout the area. Fl. Aug.-Oct. Murty & Singh 56.

Ipomoea batatas Lamk. Hindi Shakarkandi.

Cultivated for its tubers. Fl. Dec.-Jan. Murty & Singh, Dec. 1959.

Ipomoea leari Paxt.

Cultivated in gardens. Fl. Aug.-Nov. Murty & Singh Sept. 1958.

Ipomoea cairica (Linn.) Sweet.=*Ipomoea palmata* Forsk.=*Ipomoea pulchella* Wt. non Roth.

Common in gardens. Fl. Aug.-Nov. Murty & Singh Sept. 1958.

Ipomoea purpurea Roth.

Cultivated in gardens. Fl. Aug.-Nov. Murty & Singh Aug. 1958.

Ipomoea carnea Jacq. Hindi Huzbuck.

Commonly cultivated as a hedge plant. Fl. almost all the year round. Murty & Singh 717.

Ipomoea quamoclit Linn.=*Quamoclit pinnata* (Desr.) Boj.

Cultivated at some places; flowers bright crimson. Fl. Aug.-Oct. Murty & Singh 420.

SOLANACEAE

Solanum nigrum Linn. Hindi Makoi.

A common weed often in cultivated land. Fl. most part of the year. Murty & Singh 438.

Solanum Xanthocarpum Schrad & Wendl. Hindi Kateli.

Common in waste land and by road sides. Fl. most part of the year. Murty & Singh 252.

Solanum indicum Linn.

Frequent in waste land. Fl. most part of the year. Murty & Singh 293.

Solanum tuberosum Linn. Hindi Alu.

Cultivated in cold season. Murty & Singh Feb. 1958.

Solanum melongena Linn.

Cultivated. Fl. July-Sept. Murty & Singh Sept. 1958.

Physalis minima Linn. Hindi Jangli Rasbherry.

Common in waste places. Fl. July-Oct. Murty & Singh 34.

Physalis peruviana Linn. Hindi Rasbherry.

Cultivated for its fruits. Murty & Singh Oct. 1959.

Withania somnifera Dunal. Hindi Asgand.

Frequent in waste land. Fl. June-Nov. Murty & Singh 190.

Nicotiana tabacum Linn. Hindi Tambakhu.

Commonly cultivated. Murty & Singh Dec. 1959.

Nicotiana plumbaginifolia Viv.

An introduced weed, common in cultivated land. Fl. March-April. Murty & Singh 163.

Datura stramonium Linn.

Tall annual with white flowers. Common in waste land. Fl. Aug.-Nov. Murty & Singh 463.

**Datura innoxa* Mill.=*Datura metel* Sims non Linn.

This is an introduced American plant mentioned in Indian Floras under the wrong name of *D. metel* Linn. Frequent in waste land; flowers purple. Fl. Aug.-Oct. Murty & Singh 183.

Lycopersicum esculentum Mill.=*Solanum lycopersicum* Linn. Hindi Tamatar.

Cultivated. Murty & Singh Aug. 1958.

Capsicum annuum Linn. Hindi Mirch.

Cultivated. Fl. Aug.-Sept. Murty & Singh 146.

SCROPHULARIACEAE

Verbascum coromandelianum (Vahl) O. Ktze.=*Celsia coromandeliana* Vahl.

A frequent weed. Flowers yellow. Fl. Feb.-April. Murty & Singh 630.

Antirrhinum orontium Linn.

Fl. Jan.-April. Murty & Singh 561.

Bacopia monnieri (Linn.) Pennell.=*Herpestis monnieria* Benth.=*Moniera cuneifolia* Michx.

A creeping herb with bluish white flowers. Abundant in wet places forming carpet. Fl. July-Dec. Murty & Singh 70.

Mazus japonicus (Thunb.) O. Kuntze.=*Mazus rugosus* Lour.

This small herb is common in damp shady places. Fl. Dec.-April. Murty & Singh 466.

Stemodia viscosa Roxb.

Herb with violet flowers, occasionally seen in marshy places. Fl. Dec.-Jan. Murty & Singh 719.

Dopatrium junceum Buch-Ham.

Rare, in rice fields. Flowers pinkish. Fl. Aug.-Sept. Murty & Singh 663.

Lindernia crustacea (Linn.) F. V. Mueller.=*Vandellia crustacea* (Linn.) Benth.

Common in damp places. Fl. July-Dec. Murty & Singh 502.

Lindernia multiflora (Roxb.) Mukerjee.=*Vandellia multiflora* G. Don.

Occasional in muddy and wet places. Fl. July-Sept. Murty & Singh 85.

Lindernia ciliata (Colsm.) Pennell.=*Bonnaya brachiata* Link. & Otto.

Common in damp shady places. Fl. July-Sept. Murty & Singh 53.

Bonnaya veronicaefolia Spring.

Occur in wet places, not common. Fl. July-Dec. Murty & Singh 503.

Scoparia dulcis Linn.

A foetid herb with white flowers; common in waste land. Fl. March-June. Murty & Singh 246.

Veronica anagallis Linn.

Very common in wet and marshy places. Fl. Feb.-April. Murty & Singh 545.

Veronica agrestis Linn.

A common weed of cultivated land. Fl. Jan.-March. Murty & Singh 550.

Striga euphrasioides Benth.

Common in open grassy places and cultivated fields. Fl. Oct.-Dec. Murty & Singh 216.

Lindenbergia urticaefolia Link. & Otto.

Erect herb with purple flowers. Common on walls of old ruins and on rocks. Fl. July-Dec. Murty & Singh 440.

OROBANCHACEAE

Orobanche aegyptiaca Pers.

A parasite with blue flowers, often found on the members of Cruciferae. Fl. Nov.-Feb. Murty & Singh 534.

LENTIBULARIACEAE

Utricularia stellaris Linn.

An aquatic herb with a whorl of floats at the base of peduncles; flowers yellow. Common in ponds and ditches. Fl. Sept.-Nov. Murty & Singh 417.

Utricularia flexuosa Vahl.

Somewhat similar to *U. stellaris* but without floats. Occur in same localities but not so common. Fl. Oct.-Nov. Murty & Singh. 710.

BIGNONIACEAE

Heterophragma adenophyllum Seem.

A handsome tree with brownish yellow flowers. Introduced by the Forest Department. Fl. Sept.-Oct. Murty & Singh 377.

Jacaranda mimosaefolia G. Don =*Jacaranda ovalifolia* R. Br. =*Jacaranda acutifolia* Humb. & Bonpl.

Cultivated in gardens. Fl. April-May. Murty & Singh 765.

Tecoma stans (Linn.) H. B. K.

A shrub with yellow Flowers; cultivated in gardens. Fl. Jan.-April. Murty & Singh 730.

PEDALIACEAE

Sesamum indicum Linn. Hindi Til.

Cultivated as well as growing wild. Fl. Aug.-Oct. Murty & Singh 46.

Martynia annua Linn. =*Martynia diander* Glax. Hindi Bichhu.

Tall herb with drooping pink flowers. Common in waste places. Fl. July-Sept. Murty & Singh 19.

**Pedalium murex* Linn. Hindi Vilayti gokhru.

Herb with bright yellow flowers, capsule armed with 4 spines. Frequent in dry sandy places. Fl. July.-Sept. Murty & Singh 47.

ACANTHACEAE

Elytraria acaulis(Linn. f.) Lindau.=*Tubiflora acaulis* 0. Ktze.

Frequent in rocky places. Fl. Sept.-Nov. Murty & Singh 552.

Blepharis maderaspatensis (Linn.) Heyne ex Roth.=*Blepharis boerhavaefolia pers.*

Common in dry and partial shady places. Fl. Aug.-March. Murty & Singh 578.

Blepharis molluginifolia Pers.

Much smaller plant than *B. moderaspatensis* with sub-sessile leaves. Fl. Sept.-Nov. Murty & Singh 435.

Asteracantha longifolia (Linn.) Nees.=*Hygrophila spinosa* T. Anders.

Frequent along ditches and in muddy places, growing in patches. Fl. Sept.-Nov. Murty & Singh. 670.

Dipteracanthus prostratus (Poir) Ness.=*Ruellia prostrata* Poir.=*Ruellia prostrata* Poir. var. *dejecta* Clarke.

Common in partial shady places. Fl. July-Feb. Murty & Singh 64.

**Ruellia tuberosa* Linn.

Erect herb with deep blue flowers. Frequent. Fl. July-Sept. Murty & Singh 297.

Hemigraphis hirta T. Anders.

Frequent in damp places growing in dense patches. Fl. March-May. Murty & Singh 731.

Andrographis echioides Nees.

Occasionally met with in the area. Fl. Aug.-Dec. Murty & Singh 701.

Barleria prionitis Linn. Hindi Kala-bansa.

Prickly under-shrub with yellow flowers. Common in hedges in rocky places. Fl. Oct.-March. Murty & Singh 518.

Barleria cristata Linn.

Diffuse under-shrub with blue purple flowers. Common in open forest. Fl. Sept.-Nov. Murty & Singh 443.

Justicia quinqueangularis Koen.

Frequent in wet and marshy places. Flowers pink in lax spikes. Fl. Sept.-Nov. Murty & Singh 501.

Justicia simplex D. Don.

Common in open grassy places. Fl. Oct.-Feb. Murty & Singh 285.

Justicia gendarussa Burm.

Cultivated as a hedge plant. Fl. Feb.-April. Murty & Singh 767.

Adhatoda vesica Nees.=*Justicia adhatoda* Linn. Hindi Bansa.

Very common throughout the area. Fl. Feb.-March. Murty & Singh 549.

Peristrophe bicalyculata Nees.

Very common in hedges and in cultivated and waste land. Fl. Nov.-March. Murty & Singh 451.

Rungia repens Nees.

Frequent in moist places growing in dense patches. Fl. Sept.-Dec. Murty & Singh 388.

Rungia pectinata (Linn.) Ness. =*Rungia parviflora* Nees. var. *pectinata* C. B. Clarke.

A common weed in open grassy places. Fl. most part of the year. Murty & Singh 437.

VERBENACEAE

Lantana indica Roxb.

A shrub with pale purplish flowers; Frequent. Fl. most part of the year. Murty & Singh 157.

Phyla nodiflora (Linn.) Greene. =*Lippia nodiflora* A. Rich.

This perennial herb is fairly common on wet ground. Fl. almost all the year round. Murty & Singh 140.

Verbena officinalis Linn.

Frequent on waste land. Fl. June.-Aug. Murty & Singh 496.

Tectona grandis Linn. f. Hindi Saigon.

A large tree planted by the Forest Department. Fl. June-Aug. Murty & Singh 772.

Gmelina arborea Roxb. Hindi Khamar.

Rarely seen in Forest area. Fl. March-April. Murty & Singh 631.

Vitex negundo Linn. Hindi Mala.

Fairly common throughout the area. Fl. most part of the year. Murty & Singh 100.

Clerodendron phlomidis Linn. f.

A large shrub with white flowers. Frequent in hedges and near habitations. Fl. most part of the year. Murty & Singh 517.

Clerodendrum indicum (Linn.) Ktze. = *Clerodendron siphonanthus* R.Br.

Tall herb with white flowers and red persistent calyx. Frequent in open places, particularly near water courses on moist soil. Fl. June-Sept. Murty & Singh 275.

Duranta repens Linn. =*Duranta plumieri* Jacq.

Grown as a hedge plant. Fl. most part of the year. Murty & Singh 768.

Nyctanthes arbor-tristis Linn. Hindi Har singar.

This genus so far regarded as a member of Oleaceae has been transferred to the family Verbenaceae under a new sub-family Nyctanthoideae (Airyshaw 1952). Stant (1952) pointed out several morphological and anatomical features to differ from those in Oleaceae but in favour of Verbenaceae.

Growing wild in forest area; fairly common. Fl. Sept.-Oct. Murty & Singh 265.

LABIATAE

Ocimum sanctum Linn. Hindi Tulsi

Growing near temples. Fl. Oct.-Dec. Murty & Singh Nov. 1958.

Ocimum americanum Linn. = *Ocimum canum* Sims. Hindi Ban-tulsi.

Running wild near excavations. Fl. Aug.-Oct. Murty & Singh 16.

Ocimum basilicum Linn. Kali-tulsi.

Occasionally found near temples. Fl. Oct.-Dec. Murty & Singh 497.

Orthosiphon pallidus Royle

A woody herb with white or blue flowers. Rare. Fl. July.-Oct. Murty & Singh 88.

Anisomeles indica (Linn.) O. Kuntze. = *Anisomeles ovata* R. Br.

A strong smelling herb with pale purple flowers. Common in open forest. Fl. Sept.-Nov. Murty & Singh 193.

Leucas urticaefolia R. Br.

Frequent on hillock near excavations. Fl. Nov.-Feb. Murty & Singh 465.

Leucas aspera Spreng.

Common throughout the area particularly in cultivated land. Fl. July-Dec. Murty & Singh 108.

Leucas cephalotes Spreng. Hindi Ghumma.

Common in cultivated fields and waste ground. Fl. Aug.-Dec. Murty & Singh 13.

Nepeta hindostana (Roth.) Haines. = *Nepeta ruderalis* Buch.-Ham.

An aromatic herb with bluish purple flowers. Occasional in damp places. Fl. March-June. Murty & Singh 121.

Salvia plebeia R. Br.

Common in damp places. Fl. March-April. Murty & Singh 598.

**Mentha piperita* Linn. Hindi Jangli podina.

Herb with lilac flowers. Occasionally met with in wet places on river banks. Fl. Aug.-Sept. Murty & Singh 664.

Mentha viridis Linn. Hindi Podina.

Cultivated. Murty & Singh Aug. 1958.

NYCTAGINACEAE

Boerhaavia diffusa Linn.

Very common in grassy waste places. Fl. July-Oct. Murty & Singh 38, 41, 105.

Boerhaavia repanda Willd.

Straggling amongst bushes; common. Fl. Aug.-March. Murty & Singh 104.

Mirabilis jalapa Linn.

Often met with near temples. Fl. Sept.-Oct. Murty & Singh 241.

Bougainvillea spectabilis Willd.

Commonly cultivated in gardens. Fl. Feb.-May. Murty & Singh 766.

AMARANTACEAE

Celosia argentea Linn. Hindi Murg ka phul.

Common in cultivated fields. Fl. Sept.-Dec. Murty & Singh 375.

Digera muricata (Linn.) Mart. = *Digera arvensis* Forsk.

A common weed of cultivated land. Fl. Aug.-Dec. Murty & Singh 147.

Amarantus spinosus Linn.

A common weed. Fl. most part of the year. Murty & Singh 97.

Amarantus viridis Linn. Hindi Chaulai.

Fairly common. Fl. July-Feb. Murty & Singh 124.

Amarantus polygamus Linn.

Frequent in cultivated land. Fl. Sept.-Dec. Murty & Singh 409.

Aerva javanica (Burm. f.) Spreng. = *Aerva tomentosa* Forsk. = *Aerva javanica* Juss.

A tomentose herb met with in dry sandy places. Not common. Fl. Sept.-Nov. Murty & Singh 398.

Aerva sanguinolenta (Linn.) Blume. = *Aerva scandens* Wall.

A straggling undershrub, very common throughout the forest area, sometimes climbing amongst bushes. Fl. most part of the year. Murty & Singh 30, 101.

Aerva lanata Juss.

Frequent in waste land. Fl. Nov.-Jan. Murty & Singh 481.

Achyranthes aspera Linn. Hindi Chirchita.

Fairly common in waste land. Fl. Oct.-Jan. Murty & Singh 461.

Pupalia lappacea Juss.

This straggling under shrub is frequent amongst bushes. Fl. Aug.-Oct. Murty & Singh 23.

Alternanthera sessilis R. Br.

Very common in wet places particularly near water edges. Fl. Aug.-Dec. Murty & Singh 195.

**Alternanthera repens* (Linn.) of Kuntee. = *Alternanthera echinata* Sm.

A prostrate herb with shining white axillary spikes. Frequent in waste land. Fl. Oct.-Jan. Murty & Singh 498.

**Gomphrena celosioides* Mart. = *Gomophrena decumbens* Jacq.

Very common by road sides. Fl. July-Oct. Murty & Singh 65.

Gomphrena globosa Linn.

Found as an escape from garden. Fl. Aug.-Oct. Murty & Singh 706.

CHENOPODIACEAE

Chenopodium album Linn. Hindi Bathua.

Commonly met with in cultivated ground. Fl. March-June. Murty & Singh 769.

Chenopodium murale Linn.

Very common in waste places. Fl. July-Nov. Murty & Singh 99, 499.

**Chenopodium ambrosioides* Linn. Hindi Khad-bathua.

Frequent in waste places. Fl. Aug.-Oct. Murty & Singh 397.

Kochia indica Wight.

Occasionally met with in dry sandy places. Fl. Oct.-Nov. Murty & Singh 478.

Spinacia oleracea Linn. Hindi Palak.

Cultivated in cold season. Murty & Singh Dec. 1958.

POLYGONACEAE

Polygonum plebejum R. Br.

A variable prostrate herb with pink flowers. Very common in waste land and cultivated ground. Fl. Feb.-May. Murty & Singh 203, 586, 639, 640.

Polygonum glabrum Willd.

Frequent in marshy places and near water edges. Stipules, eciliate, flowers pink. Fl. Aug.-Dec. Murty & Singh 90.

Polygonum serrulatum Lagasc.

Fairly common in marshes, stipules with long ciliate bristles, flowers white. Fl. Aug.-Jan. 61, 672.

Polygonum hydropiper

Frequent in wet places, flowers pink. Fl. Aug.-Dec. Murty & Singh 500.

Rumex dentatus Linn.

Very common throughout the area in marshy and wet places. Fl. Feb.-April. Murty & Singh 572.

ARISTOLOCHIACEAE

Aristolochia bracteata Retz. Hindi Kirmar.

A solitary plant was collected in Sept. 1954 by the present authors

LORANTHACEAE

Dendrophthoe falcata (Linn. f.) Etting. =*Loranthus falcatus* Linn. f. =*Loranthus longiflorus* Desr. var. *falcata*. Hindi Banda.

A branch parasite common on trees particularly *Ficus* spp. and *Dalbergia sissoo*. Fl. Nov.-March. Murty & Singh 39, 648.

EUPHORBIACEAE

Euphorbia dracunculoides Lamk.

A common weed of wheat fields. Fl. Feb.-May. Murty & Singh 592.

Euphorbia prolifera Buch.-Ham.

Frequent. Fl. March-May. Murty & Singh 565.

Euphorbia hypericifolia Linn.

Frequent in open places. Fl. Sept.-Dec. Murty & Singh 226.

Euphorbia hirta Linn.

A very common weed of the area. Murty & Singh 5.

Euphorbia thymifolia Linn.

Common in cultivated land. Fl. most part of the year. Murty & singh 150.

Euphorbia pulcherrima Willd.

Cultivated in gardens. Fl. Nov.-Feb. Murty & Singh 705.

Securinega virosa (Roxb. ex Willd.) Pax & Hffm. = *Flueggea microcarpa* Bl. Hindi Dalme.

This straggling shrub is frequent in forest area. Fl. June-Sept. Murty & Singh 248.

Melanthesa rhamnoides (Rete.) Bl. = *Breynia rhamnoides* Muell.

Fairly common in open forest. Fl. May.-Sept. Murty & Singh 391.

Phyllanthus maderaspatensis Linn. Hindi Hazarmani.

Frequent in open places. Fl. Aug.-Nov. Murty & Singh 227.

Phyllanthus niruri Linn. Hindi Hazara.

A common weed of waste and cultivated land. Fl. July.-Oct. Murty & Singh 148.

Emblica officinalis Gaertn. = *Phyllanthus emblica* Linn. Hindi Amla

Cultivated. Fl. March.-May. Murty & Singh 770.

**Croton bonplandianum* Baill. = *Croton sparsiflorum* Morong.

An introduced weed, very common by road sides and in waste land. Fl July.-Nov. Murty & Singh 96.

Acalypha indica Linn.

Common. Fl. July-Dec. Murty & Singh 158.

Acalypha ciliata Forsk.

Frequentt. Fl. Aug.-Nov. Murty & Singh 14.

Ricinus communis Linn. Hindi Arandi.

Frequent in waste places, growing wild. Fl. Nov.-March. Murty & Singh 553.

Sapium sebiferum Roxb. Hindi Tarcharbi.

Common in marshy localities. Fl. Male April-May; female June-Aug. Murty & Singh 665 (male), 737 (female).

CANNABINACEAE

Cannabis sativa Linn. Hindi Bhang, Ganja, Charas.

Fairly common in waste land. Fl. most part of the year. Murty & Singh 60 (male), 60A (female).

MORACEAE

Morus indica Linn. Hindi Tut.

Cultivated by Forest Department. Fl. March-April. Murty & Singh 620.

Morus laevigata Wall. Hindi Sahatut

Cultivated. Fl. March-April. Murty & Singh 575.

Morus alba Linn.

Introduced by Forest Department. Fl. March-April. Murty & Singh 575A.

Sterblus asper Lour. Hindi Kuchna

Frequent with in the area. Fl. March-April. Murty & Singh 611.

Ficus bengalensis Linn. Hindi Bargad.

Few plants, probably self sown. Murty & Singh 779.

Ficus religiosa Linn. Hindi Pipal.

Commonly planted near temples, etc. Murty & Singh 775.

Ficus lacor Buch.-Ham. =*Ficus infectoria* Roxb. Hindi Pilkhan.

Few plants have been observed with in the area. Probably planted. Murty & Singh 771.

Ficus palmata Forsk. Hindi Anjir.

Frequent in forest area. Murty & Singh 284.

Ficus glomerata Roxb. Hindi Gular.

Occasionally planted near villages. Murty & Singh 776.

Broussonetia papyrifera Vent.

Planted by Forest Department. Fl. March-April. Murty & Singh 621.

URTICACEAE

Pouzolzia pentandra Benn.

A variable herb with white flowers, very common in marshy places. Fl. Sept.-Dec. Murty & Singh 336.

CASUARINACEAE

Casuarina equisetifolia Forst.

Cultivated. Murty & Singh 777.

SALICACEAE

Salix tetrasperma Roxb.

Frequent in marshes. Fl. Aug.-Sept. Murty & Singh 373, 698.

CERATOPHYLLACEAE

Ceratophyllum demersum Linn.

This submerged aquatic herb is very common in ponds, etc. Fl. July-Sept. Murty & Singh 359, 678.

HYDROCHARITACEAE

Hydrilla verticillata Royle.

A common submerged fresh water herb with white flowers; very common in ponds and jheels. Fl. July-Sept. Murty & Singh 360.

Vallisneria spiralis Linn.

Occasionally met with in slow running water. Fl. Feb.-April. Murty & Singh 535.

ORCHIDACEAE

Zeuxine sulcata Lindl.

A small herb with pink flowers in terminal racemes. Occasionally met with in moist, open, grassy places. Fl. Feb.-March. Murty & Singh 538.

MUSACEAE

Musa paradisiaca Linn. Hindi Kela.

Cultivated for its fruits. Fl. April-July. Murty & Singh. July 1958.

ZINGIBERACEAE

Curcuma longa Linn. Hindi Haldi.

Cultivated. Fl. Sept.-Oct. Murty & Singh Sept. 1959.

Zingiber officinalis Rose. Hindi Adrak.

Occasionally cultivated. Fl. July-Sept. Murty & Singh Aug. 1959.

AMARYLLIDACEAE

Agave Sp.

Cultivated at the edges of fields. Fl. July-Sept. Murty & Singh 419.

DIOSCOREACEAE

Dioscorea bulbifera Linn.

This climber is common on bushes in forest area. Fl. July-Sept. Murty & Singh 339 (male); 339A (Female).

LILIACEAE

Asparagus racemosus Willd. Hindi Satmuli.

Occasionally met with in the area. Flowers fragrant white. Fl. Sept.-Oct. Murty & Singh 223.

Gloriosa superba Linn. Hindi Kulhari.

A leaf climber with inverted showy flowers. Frequent among bushes and hedges in partial shady places. Fl. July-Sept. Murty & Singh 255.

Asphodelus tenuifolius Cav. Hindi Jangli-piazi.

Common in cultivated land. Fl. Feb.-May. Murty & Singh 609.

Allium cepa Linn. Hindi Piyaj.

Commonly cultivated. Fl. April-May. Murty & Singh May 1959.

Allium sativum Linn. Hindi Lahsun.

Occasionally cultivated. Fl. April-May. Murty & Singh May 1959.

PONTEDERIACEAE

Monochoria hastaefolia Presl.

Common in marshes. Fl. Aug.-Sept. Murty & Singh 86.

Monochoria vaginalis Presl.

Frequent in rice fields and marshy localities. Fl. Aug.-Oct. Murty & Singh 76.

**Eichhornia crassipes* Solms. Hindi Samundar sokh.

This beautiful introduced American plant with blue flowers is fairly common in ponds, ditches and slow running water. Fl. May-Oct. Murty & Singh 416.

COMMELINACEAE

Commelina nudiflora Linn.

Common in open damp places. Fl. Aug.-Oct. Murty & Singh 21, 280.

Commelina benghalensis Linn.

Fairly common in damp grassy places. Fl. July-Nov. Murty & Singh 12.

Commelina attenuata Koen. ex. Vahl.

Not uncommon. Fl. Aug.-Oct. Murty & Singh 211, 382.

Commelina obliqua Buch-Ham.

Fairly common throughout the area. Fl. July-Nov. Murty & Singh, 38, 182.

Murdannia nudiflorum (Linn.) Brenan. = *Aneilema nudiflorum* R. Br.

A small herb with blue flowers. Frequent in damp places. Fl. July-Sept. Murty & Singh 80.

Cyanotis cristata Schult. f.

Frequent in damp and partial shady places sometimes even growing epiphytically on trees. Fl. Aug.-Nov. Murty & Singh 66, 139, 434.

Cyanotis axillaris Schult f.

Frequent in wet places. Fl. Aug.-Nov. Murty & Singh 244.

JUNCACEAE

Juncus bufonius Linn.

A grass like tufted herb with pale green flowers. Common in wet muddy places. Fl. Feb.-March. Murty & Singh 666.

PALMACEAE

Phoenix sylvestris Roxb. Hindi Khajur.

Growing wild in forest area. Fl. March.-May. Murty & Singh March 1959.

THYPHACEAE

Typha elephantina Roxb. Hindi Patera.

A tall blursh, flowers in compact spikes. Abundant in marshes. Fl. July.-Sept. Murty & Singh 86.

AROIDEAE

Colocasia esculentum (Linn.) Schott. =*Colocasia antiquorum* Schott. Hindi Arvi, Ghuian.

Cultivated. Fl. July.-Sept. Murty & Singh August, 1959.

LEMNACEAE

Spirodela polyrrhiza Schleid.

Common in rainy season in ponds and ditches. Murty & Singh 361.

Lemna paucicostata Hegelm.

Abundant in rainy season in ponds and ditches. Murty & Singh 661.

† **Lemna trisulca* Linn.

Common in still waters. Murty & Singh 679.

Wolffia microscopica Kurz.

Common during rains. Murty & Singh 536.

ALISMACEAE

Sagittaria sagittifolia Linn.

Leaves emerged, flowers white with a purple claw. Common in marshes. Fl. March-May. Murty & Singh 721.

Sagittaria guayanensis H. B. K.

Occasionally seen in ponds during rainy season. Leaves floating, flowers white. Fl. Aug.-Sept. Murty & Singh 668.

APONOGETONACEAE

† **Aponogeton natans* (Linn.) Engl. & Krause. =*Aponogeton monostachyon* Linn. f.

This aquatic herb is frequent in ditches; flowers blue. Fl. Aug.-Nov. Murty & Singh 169.

POTAMOGETONACEAE

Potamogeton crispus Linn.

Submerged aquatic herb with white flowers. Common in still and slow running water. Fl. Feb.-April. Murty & Singh 600.

Zannichellia palustris Linn.

Common in ponds and ditches. Fl. Feb.-March. Murty & Singh 540.

NAIDACEAE

Nais minor Allione.

Frequent in ponds and ditches. Fl. Aug.-Sept. Murty & Singh 541.

ERIOCAULACEAE

Eriocaulon sieboldianum Sieb.

This tufted annual is commonly seen in drying up paddy fields. Fl. Oct.-Nov. Murty & Singh 438.

CYPERACEAE

Cyperus difformis Linn.

Frequent in sandy places. Fl. Sept.-Dec. Murty & Singh 528.

Cyperus amabilis Vahl.

Common in the area particularly in paddy fields. Spikelets dark brown. Fl. June-Nov. Murty & Singh 264.

Cyperus niveus Retz.

Frequent in open forest; spikelets dirty white. Fl. June.-Aug. Murty & Singh 132.

Cyperus aristatus Rottb.

Small annual, spikelets in dense heads. Frequent in sandy places. Fl. Sept.-Nov. Murty & Singh 272.

Cyperus iria Linn.

Fairly common in paddy fields and also at other places. Fl. Aug.-Dec. Murty & Singh 198.

**Cyperus alulatus* Retz.

Very similar to *C. iria*. Frequent on wet muddy soil. Fl. Aug.-Oct. Murty & Singh 220, 693.

Cyperus exaltatus Retz.

Frequent in the area. Fl. Aug.-Nov. Murty & Singh 214.

Cyperus digitatus Roxb.

Frequent in marshy places. Fl. July-Sept. Murty & Singh 152.

Cyperus rotundus Linn. Hindi Motha..

A common weed of lawns and cultivated land. Fl. July-Dec. Murty & Singh 71, 192.

Cyperus distans Linn. f.

Frequent in wet and marshy places. Fl. July-Sept. Murty & Singh 270.

Pycerus globosus Reich.

Very common in marshy places; spikelets pale brown. Fl. Aug.-Nov. Murty & Singh 77, 93, 136.

Pycerus pumilis Turrill.

A small tufted annual with pale silvery spikelets; frequent in sandy localities. Fl. Aug.-Oct. Murty & Singh 287.

Juncellus alopecuroides C. B. Clarke.

A tall marsh herb with pale brown spikelets; fairly common. Fl. most part of the year. Murty & Singh 151, 548, 653, 654.

Juncellus laevigatus C. B. Clarke.

Abundant in wet places forming mats. Fl. Aug.-Sept. Murty & Singh 78, 173.

Juncellus pygmaeus C. B. Clarke.

This tufted annual with greenish white spikelets is frequent in damp shady places. Fl. July-Oct. Murty & Singh 362.

**Juncellus inundatus* C. B. Clarke.

Common in marshes and paddy fields; spikelets choklate coloured in loose spikes. Fl. July-Oct. Murty & Singh 671.

Kyllinga triceps Rottb.

Rhizome short, spikes ovoid and usually 3-nate. Common in grassy places under partial shade. Fl. July-Nov. Murty & Singh 83.

†**Kyllinga cylindrica* Nees.

Growing scattered in moist shady places; spikes cylindric. Fl. Aug.-Sept. Murty & Singh 194.

Kyllinga monocephala Rottb.

Occur more commonly in same localities as *K. triceps;* rhizome creeping. Fl. July-Oct. Murty & Singh 348.

Mariscus dilutus Nees.

Frequent. Fl. July-Sept. Murty & Singh 269.

Mariscus paniceus Vahl. var. *roxburghianus* C. B. C.

Frequent in sandy places. Fl. July-Sept. Murty & Singh 73.

Heleocharis artopurpurea Kunth.

A small tufted annual; frequent in dried up rice fields. Fl. April-Oct. Murty & Singh 355.

Eleocharis plantaginea R. Br.

A rush-like caespitose herb; frequent in marshes and shallow ponds. Fl. Oct.-Dec. Murty & Singh 486.

Fimbristylis diphylla Vahl.

Frequent in marshes during rainy season. Fl. July-Oct. Murty & Singh 74, 75.

Fimbristylis spathacea Roth.

Occasional. Fl. Aug.-Nov. Murty & Singh 504.

Fimbristylis monostachya Hassk.

A caespitose marsh herb; fairly common. Fl. July-Sept. Murty & Singh 393.

Fimbristylis miliacea Vahl.
Frequent in marshy places. Fl. July-Sept. Murty & Singh 273.

Filmbristylis aestivalis Vahl.
Frequent on damp soil. Fl. Sept.-Dec. Murty & Singh 516.

Bulbostylis barbata Kunth.
Common in sandy places. Fl. July-Dec. Murty & Singh 128.

Scirpus mucronatus Linn.
Fairly common in marshes. Fl. Oct.-Nov. Murty & Singh 669.

Scirpus supinus Linn.
Frequent on wet soil, sometimes in drying up paddy fields. Fl. Oct.-Dec Murty & Singh 509.

Scirpus roylei (Nees) Parker.
Common in marshes. Fl. July-Nov. Murty & Singh 505.

Scirpus lacustaris Linn.
Frequent in marshy localities. Fl. Feb.-April. Murty & Singh 543.

Scirpus maritimus Linn.
Common in marshy places. Fl. Feb.-April. Murty & Singh 652.

Scirpus affinis Roth. = *Scirpus maritimus* var. *affinis* C. B. C.
Occurs in same localities as *S. maritimus* but not so common. Fl. Feb.-April. Murty & Singh 652A.

Carex cernua Bott.
Common in marshes. Fl. March.-April. Murty & Singh 544.

GRAMINEAE

Dendrocalamus sp.
Murty & singh Sept. 1959.

Poa annua Linn.
Fl. Feb.-April. Murty & Singh 166.

Lolium temulentum Linn.
Fl. Sept.-Oct. Murty & Singh 256.

Hordeum vulgare Linn. Hindi Jau.
Murty & Singh Feb. 1959.

Triticum aestivum Linn. = *Triticum vulgare* Vill. Hindi Gehun.
Murty & Singh 607.

Arundo donax Linn. Hindi Nal.
Fl. Oct.-Dec. Murty & Singh 328.

Phragmites karka (Retz.) Trin. ex Steud. = *Phragmites maxima* (Forsk.) Chiovenda. Hindi Bansi.
Fl. Sept.-Jan. Murty & Singh 249, 442, 555, 707.

Desmostachya bipinnata (Linn.) Stapf. Hindi Dab.
Fl. June-Sept. Murty & Singh 571.

Eragrostis coarctata Stapf. ex. Hook. f.
Fl. Sept.-Dec. Murty & Singh 559.

Eragrostis ciliaris (Linn.) Link.
Fl July-Oct. Murty & Singh 350.

Eragrostis unioloides (Retz.) Nees. ex Steud.
Fl. rainy season. Murty & Singh 94.

Eragrostis tenella (Linn.) Beauv. ex R. & S.
Fl. Sept.-Dec. Murty & Singh 126

Eragrostis japonica (Thumb.) Trin.=*Eragrostis interrupta* var. *tenuissima* Stapf.
Fl. Oct.-Dec. Murty & Singh 445.

Eragrostis chariis (Schult) Hitche.=*Eragrostis elegantula* (Kunth.) Steud.
Fl. Sept.-Feb. Murty & Singh 403.

**Eragrostis tremula* Hochst.
Fl. Aug.-Nov. Murty & Singh 529.

Eragrostis megastachya (Koel.) Link.=*Eragrostis major* Hochst.
Fl. July-Oct. Murty & Singh 507.

**Eragrostis poaeoides* Beauv.=*Eragrostis minor* Hochst.
Fl. June.-Oct. Murty & Singh 125.

Eragrostis pilosa (Linn.) Beauv.
Fl. Aug.-Dec. Murty & Singh 15.

†**Eragrostis nigra* Nees.
Fl. Aug.-Nov. Murty & Singh 235.

Eleusine indica (Linn.) Gaertn.
Fl. Aug.-Oct. Murty & Singh **329.**

Eleusine coracana Gaertn. Hindi Mandva.
Fl. Sept.-Oct. Murty & Singh 407.

Achrachne verticillata (Roxb.) Chiov.=*Eleusine verticillata* Roxb.
Fl. Aug.-Oct. Murty & Singh 127.

Dactyloctenium aegyptium (Linn.) P. Beauv. Hindi Makra.
Fl. Aug.-Nov. Murty & Singh 123.

Leptochloa filiformis Roem. & Sch.
Fl. Aug.-Nov. Murty & Singh 94.

Sporobolus diander Beauv.
Fl. Aug.-Oct. Murty & Singh 188.

Chloris dolichostachya Lag.=*Chloris incompleta* Roth.
Fl. Oct.-Nov. Murty & Singh 674.

Chloris inflata Link.=*Chloris barbata* (Linn.) Sw. Hindi Jargi.
Fl. Oct.-Feb. Murty & Singh 490.

Cynodon dactylon (Linn.) Pers. Hindi Dub.
Fl. most part of the year. Murty & Singh 603.

Avena sterilis Linn. var. *culta*=*Avena sativa* auct. non Linn. Hindi Jai.
Fl. Murty & Singh 613.

Polypogon monspelensis Desf.
Fl. March-April. Murty & Singh 586.

Alopecurus nepalensis Trin.
Fl. Dec. Murty & Singh 562.

Aristida funiculata Trin. & Rupr.
Fl. Sept.-Oct. Murty & Singh 209.

Aristida hystrix Linn. f.
Fl. almost all the year round. Murty & Singh 310.

Aristida adscencionis Linn. Hindi Lappa.
Fl. Sept.-Dec. Murty & Singh 237.

Phalaris minor Retz.
Fl. March-April. Murty & Singh 537.

Oryza sativa Linn. Hindi Dhan.
Fl. Oct.-Nov. Murty & Singh 333, 376, 711.

Hygroryza aristata Nees.
Fl. Oct.-Nov. Murty & Singh 423, 677.

Perotis indica (Linn.) O. Ktze.
Fl. Sept.-Nov. Murty & Singh 9.

Tragus biflorus (Roxb.) Schult.
Fl. Aug.-Sept. Murty & Singh 321.

Arundinella pumila (Hochst) Steud.
Fl. Sept.-Nov. Murty & Singh 131.

Arundinella nepalensis Trin.
Fl. Oct.-Nov. Murty & Singh 292.

†**Isachne himalaica* Hk. f.
Fl. Sept.-Oct. Murty & Singh 401, 703.

Digitaria stricta Roth.
Fl. Aug.-Oct. Murty & Singh 129.

Digitaria sanguinalis (Linn.) Scop.
Fl. Aug.-Oct. Murty & Singh 122,

Panicum trypheron Schult. Hindi Mijhri.
Fl. Sept.-Nov. Murty & Singh 309, 695.

Panicum antidotale Retz.
Fl. Oct.-Dec. Murty & Singh 324.

Panicum maximum Jacq.
Fl. Sept.-Nov. Murty & Singh 50, 186, 696.

Echinochloa crus-galli (Linn.) P. Beauv.=*Panicum crus-galli* Linn. Hindi Sama.
Fl. Aug.-Nov. Murty & Singh 402, 424.

Echinochloa colonum (Linn.) Link=*Panicum colonum* Linn. Hindi Sawan.
Fl. Aug.-Nov. Murty & Singh 20, 69.

Paspalum scrobiculatum Linn.
Fl. Sept.-Oct. Murty & Singh 197.

Paspalidium flavidum (Retz.) Camus. =*Panicum flavidum* Retz.
Fl. Aug.-Oct. Murty & Singh 84, 187.

Paspalidium punctatum (Burm. f.) Camus. =*Panicum punctatum* Burm. f.
Fl. Sept.-Nov. Murty & Singh 356.

Urochloa panicoides P. Beauv.
Fl. rainy season. Murty & Singh 283.

Oplismenus burmanii (Retz.) P. Beauv.
Fl. Aug.-Oct. Murty & Singh 349.

Oplismenus compositus (Linn.) P. Beauv.
Fl. Sept.-Oct. Murty & Singh 231.

Eriochloa procera (Retz.) C. E. Hubb.
Fl. Sept.-Nov. Murty & Singh 676.

Brachiaria reptans (Linn.) C. A. Gard & C. E. Hubb. =*Panicum reptans* Linn.
Fl. Sept.-Nov. Murty & Singh 141.

Brachiaria ramosa (Linn.) Stapf. =*Panicum ramosum* Linn.
Fl. July-Sept. Murty & Singh 130

Setaria palmifolia (Koenig) Stapf. =*Panicum plicatum* Willd. (non Lamk).
Fl. Sept.-Oct. Murty & Singh 305.

Setaria glauca (Linn.) Beauv. =*Panicum glaucum* Linn.
Fl. Aug.-Oct. Murty & Singh 259, 308.

Setaria tomentosa (Roxb.) Kunth.
Fl. Aug.-Oct. Murty & Singh 156.

Pennisetum typhoides (Burm. f.) Stapf. & Hubb. =*Pennisetum typhoideum* Rich. Hindi Bajra.
Fl. Aug.-Sept. Murty & Singh Feb. 1959.

Cenchrus ciliaris Linn. Hindi Anjana.
Fl. Sept.-Oct. Murty & Singh 656.

Cenchrus setigerus Vahl. =*Cenchrus biflorus* Roxb.
Fl. July-Sept. Murty & Singh 308.

Cenchrus pennisetiformis Hochst & Steud.
Fl. Aug.-Dec. Murty & Singh 18, 508.

Cenchrus barbatus Schum. =*Cenchrus catharticus* Del.
Fl. July-Sept. Murty & Singh. 48.

Imperata cylindrica (Linn.) P. Beauv. Hindi Sirhu.
Fl. March-May. Murty & Singh 614.

Narenga porphyrocoma (Hence) Bor. =*Saccharum narenga*. Ham. Hindi Kanwal.
Fl. Aug.-Nov. Murty & Singh 444.

Saccharum spontaneum Linn. Hindi Kans.
Fl. Aug.-Nov. Murty & Singh 98.

Saccharum officinarum Linn. Hindi Ganna.
Fl Feb.-April. Murty & Singh 522.

Erianthus munja (Roxb.) Jesweit. =*Saccharum munja* Roxb. Hindi Munj.
Fl. Oct.-Dec. Murty & Singh 472.

Eulaliopsis binata (Retz.) C. E. Hubb. =*Andropogon binatus* Retz. Hindi Bhabar.
Fl. March-May. Murty & Singh 656.

Ischaemum rugosum Salisb.
Fl. Sept.-Nov. Murty & Singh 400.

Apluda mutica Linn. var. *eumutica* (Linn.) Pilger. =*Apluda varia* Hack. sub. sp. *mutica* Hack. Hindi Bhanjuri.
Fl. Sept.-Dec. Murty & Singh 308, 313, 513, 531.

Hackelochloa grannularis (Linn.) O. Ktze. =*Manisurus grannularis* Linn. f.
Fl. Sept.-Oct. Murty & Singh 254.

Hemarthria compressa (Linn.f.) R. Br. =*Rottboellia compressa* Linn. f. Hindi Sirhu.
Fl. Aug.-Oct. Murty & Singh 253.

Mnesithea laevis (Retz.) Kunth. =*Rottboellia laevis* Retz.
Fl. Aug.-Oct. Murty & Singh 200.

Sorghum halepense (Linn.) Pers. =*Andropogon halepensis* Brot.. Hindi Banchari.
Fl. Sept.-Nov. Murty & Singh 384.

Sorghum vulgare Pers. =*Andropogon sorghum* Brot. Hindi Jwar.
Fl. July-Sept. Murty & Singh Nov. 1958.

Chrysopogon fulvus (Spreng.) Chiov.
Fl. Sept.-Oct. Murty & Singh 312.

Vetiveria zizanioides (Linn.) Nash. Hindi Seenk, Khus.
Fl. Aug.-Oct. Murty & Singh 268.

Bothriochloa pertusa (Linn.) A. Camus. =*Andropogon pertusus* (Linn.) Willd. Hindi Chhoti-jergi.
Fl. Aug.-Oct. Murty & Singh 268.

Dicanthium annulatum (Forsk.) Stapf. =*Andropogon annulatus* Forsk. Hindi Bare-jergi, Palmaha.
Fl. Aug.-Nov. Murty & Singh 313.

Dicanthium caricosum (Linn.) Camus. =*Andropogon caricosus* Linn. var. *genuinus* Hack.
Fl. Sept.-Dec. Murty & Singh 530.

Heteropogon contortus (Linn.) Beauv. ex. R. & S. =*Andropogon contortus* Linn. Hindi Kala-lappa.
Fl. Sept.-Nov. Murty & Singh 267.

Zea mays Linn. Hindi Makka, Bhutta.
Fl. June-July. Murty & Singh Aug. 1958.

Coix lachryma-jobi Linn. Hindi Gandula.
Fl. Sept.-Dec. Murty & Singh 399, 686.

CONCLUSION

In the present work a total number of 642 species representing 405 genera from 102 families are enumerated. Out of these nearly 75% belong to Dicotyledons.

Plants belonging to the family Gramineae, Papilionaceae, Cyperaceae, Compositae and Malvaceae are more common. They are represented by 87, 67, 36, 35 and 22 species respectively.

Further, the herbaceous plants constitute the major bulk of the flora, shrubs and trees are poorly represented.

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BIBLIOGRAPHY

AIRY SHAW, H. K. 1952. Note on the taxonomic position of *Nyctanthes* L. and *Dimetra* Kerr. *Kew Bull. 1952,* 273-276.

BHATIA, C. 1955. Angiospermic vegetation of Hastinapur. *Agra University M. Sc. thesis* (unpublished).

BOR, N. L. 1941. Common grasses of the United Provinces. *Ind. For. Rec.* (*Botany*) **2.** (1).

BOR, N. L. 1952. The genus *Poa* Linn. in India. *J. Bombay Nat. Hist. Soc.* **50.** 787-838.

BRENAN, J. P. M. 1957. Notes on Mimosoideae III, *Kew Bull.* 1957 No. 1, 75-96.

CHATTERJEE, D. & BHARDWAJA, R. C. 1955. Revision of the Scrophulariaceae of the Upper Gangetic Plain and adjoining areas. *Bull. Bot. Soc. Beng.* **9**: 127-153.

CROIZAT, LEON. 1940. Notes on Indian Euphorbiaceae : *Croton bonplandianum* (*C. sparsiflorum*) and *Euphorbia perbracteata*. *J. Bombay Nat. Hist. Soc.* **39**: 573-576.

DUTHIE, J. F. 1903-1929. Flora of the Upper Gangetic Plain and of the adjacent Siwalik and Sub-Himalayan Tracts. Vols. **1-3**, Calcutta.

FYSON, P. F. 1922. The Indian species of *Eriocaulon*. *J. Indian Bot.* **3**: 12-18.

GLEASON, HENRY A. 1952. The new Britton and Brown illustrated flora of the north eastern United States and adjacent Canada. Vol. **3**, Lancaster.

HILL, A. F. 1940. Some nomenclatorial problems in *Acacia*. *Bot. Mus. Leafl. Harward Univ.* **8**: 93-105.

JAIN, R. K. 1958. Hitherto unrecorded occurence of *Datura innoxa* Mill. in the Upper Gangetic Plain and Rajasthan desert. *Curr. Sci.* **27**: 395.

KANJILAL, P. C. 1933. Forest Flora for Pilibhit, Oudh, Gorakhpur and Bundelkhand, Allahabad.

MALVILLE, R. 1958. Notes on *Alternanthera*. *Kew Bull. 1958* No. **1**, 171-175.

MUKERJEE, S. K.. 1940. A revision of the Labiatae of the Indian Empire. *Rec. Bot. Surv. India* **24**: (1) 1-228.

MUKERJEE S. K. 1945. A revision of the Indo-Burmese species of *Lindernia* Allioni. J. Indian Bot. Soc. **24**: 127-134.

MUKERJEE S. K. 1953. Vegetation of Delhi Ridge. J. Bombay Nat. Hist. Soc. **51**: 438-465.

MUKERJEE, S. K. 1954. Revision of the genus *Saccharum* Linn. Bull. Bot. Soc. **8**: 1-17.

MUKERJEE, S. K. 1958. Revision of the genus *Erianthus* Michx. (Gramineae) Llyodia **21**: 157-188.

MURTY, Y. S. & SINGH V. 1959. Angiospermic vegetation of Hastinapur. *Vijn. Paris. Anus. Pat.* **2**: 201-209.

MURTY, Y. S. & SINGH, V. 1960. Grasses of Hastinapur. *Ind. For.* **86**: 740-747.

MURTY, Y. S. & SINGH, V. 1961a. New plant records for the Upper Gangetic Plain from Meerut and its neighbourhood. *Proc. Nat. Ins. Sci. India* **27**: 13-17.

MURTY. Y. S. & SINGH, V. 1960b. Aquatic and marsh plants of Hastinapur. Uttar Bharati (in press).

RAIZADA, M. B. 1935. Contribution to Duthie's Flora of the Upper Gangetic Plain from the neighbourhood of Dehradun. *J. Indian Bot. Soc.* **14**: 155-158.

RAIZADA, M. B. 1935. Recently introduced or otherwise imperfectly known plants from the Upper Gangetic Plain. *Ibid* **14**: 339-348.

RAIZADA, M. B. 1936. Recently introduced or otherwise imperfectly known plants from the Upper Gangetic Plain. *Ibid* **15**: 149-167.

RAIZADA, M. B. 1939. Recently introduced or otherwise imperfectly known plants from the Upper Gangetic Plain. *Ind. For. Rec. (N.S.) Botany* **1**: 223-235.

RAIZADA, M. B. 1950. New or noteworthy plants from the Upper Gangetic Plain. *Ibid* **4**: 65-72.

RAIZADA, M. B. 1954. Grasses of the Upper Gangetic Plain and some aspects of their ecology. *Ind. For.* **80**: 24-46.

RAIZADA, M. B. 1958. New plant records for the Upper Gangetic Plain. *Proc. Nat. Ins. Sci. India* **24**: 198-208.

RAIZADA, M. B. 1958. Name changes in common Indian plants. *Ind. For.* **84**: 467-538.

RAIZADA, M. B. 1959. Name changes in common Indian Grasses. *Ibid.* **85**: 473-509.

RAIZADA, M. B. & CHATTERJI, R. N. 1954. A diagnostic key to the various forms of introduced mesquite (*Prosopis juliflora* DC). *Ind. For.* **80**: 675-680.

ROSS-CRAIG, STELLA. 1954. A revision of the genus *Sphaeranthus*. Hook. *Icon. Plant. V Series*. **6**: 1-90.

SANTAPAU, H. 1953. The genus *Dipteracanthus* Nees. in India. *Ind. For.* **79**: 321-323.

SANTAPAU, H. 1950. Notes on the Scrophulariaceae of Bombay. *J. Bombay Nat. Hist. Soc.* **49**: 25-49.

SANTAPAU. H. 1953. Notes on the Acanthaceae of Bombay. *J. Bombay Nat. Hist. Soc.* **51**: 349-368.

SANTAPAU, H. 1956. The Botanical exploration of India. *J. Indian Bot. Soc.* **35**: 1-6.

SANTAPAU, H. 1957. *Eclipta prostrata, E. erecta* or *E. alba* which is correct name ? *J. Bombay Nat. Hist. Soc.* **54**: 475-476.

SRIVASTAVA, R. L. 1953. Afforestation in the Kholas of Hastinapur. *Ind. For.* **7**: 344-350.

STANT, MARGARET, Y. 1952. Anatomical evidence for including *Nyctanthes* and *Dimetra* in the Verbenaceae. *Kew Bull. 1952*, 273-276.

A STUDY OF INTRAOCULAR TENSION AFTER RETROBULBAR ANESTHESIA*

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It has now become a routine to use retrobulbar injection of anesthetic solution in conjunction with topical anesthesia in cataract extraction and other intra-ocular operations, where we want complete anesthesia of the globe. The injection within the muscle cone blocks all the sensory nerves to the eye, thus rendering the operation painless. Apart from this it also causes akinesia of the extra ocular muscles by blocking the motor nerves, and lowers the intraocular tension. These form an important defence against vitreous loss and other complications during cataract extraction and other intraocular operations.

The hypotensive effect of retrobulbar anesthesia was first described by Elschnig[1] in 1927. Later on a detailed study was made by H. Gifford[2] (Jr.) (1949), Syndacher, Deutsch, and Bayard[3] (1954) and Greaves[4] (1955).

SELECTION OF CASES AND PROCEDURE

The present clinical study was made in normal cases (with respect to intraocular tension) and in established cases of different varieties of glaucoma. For intra venous injection of curare only those cases were selected who were not hypertensive, not suffering from bronchitis, bron-chiectasis or any form of diminished respiratory reserve, or renal insufficiency and were having normal motor power.

All the normal cases were devided into 10 groups, 9 groups of 5 cases each and 10th group of 2 cases. Except curare which was given intravenously, all the drugs enlisted below were used for Retrobulbar injection, each group receiving one of these drugs.

GROUP

1—Isotonic Saline, 1.5 c. c. (Control cases)
2—Novocaine 2% 1.5 c. c.
3—Novocaine 2% 1.5 c. c., Adrenaline 1: 1000, 2 drops
4—Novocaine 2% 1.5 c. c., Adrenaline 1: 1000, 2 drops,
  Hyaluronidase 8 T. R. U. per c. c. of the anesthetic sol.
5—Adrenaline 1: 1000, 0.25 c. c., Isotonic saline 1.25 c. c.

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* This is an abstract of the thesis submitted for the degree of Master of Surgery (Ophth.) of Agra University, Agra in the year 1959.

6—Hyaluronidase 24 T. R. U. (0.5 c. c.), Isotonic saline 1 c.c.
7—Xylocaine 2% 1.5 c. c.
8—Xylocaine-Epinephrine 2% 1.5 c. c.
9—Curare (Tubarine) 10 Mgm. in 2.5 mts.
10—Priscol 1 c. c. (10 Mgm.)

The doses written against their names were used for each case of that group.

All the glaucome cases were classified into 3 main groups of 5 cases each *i. e.*, Acute Conjestive, Chronic-congestive and chronic simple glaucoma. Novocain 2% 1.5 c. c. and adrenaline 1: 1000, 2 drops was used for retrobulbar injection in each case of these three groups.

W. S. Atkinson's[5] Technique was used for giving retrobulbar injection in these cases. Curare was injected intravenously, 3 Mgm. in the first minute, another 3 Mgm. in the 2nd mnt. and 4 Mgm. in the next half minute. Thus 10 Mgm. was injected in 2.5 minutes. The rate and depth of respiration was carefully watched till the effect of curare passed away.

After the injection the following observations were made :—

(1) Tension was recorded by Schiotz's tonometer every 5 mts. for 20 mts. then every 10 mts. till it came to the original level. As the actual amount of drop in tension depends on the initial level of tension, the percentage of lowering of tension would give a better figure to use for this study.

(2) The movements of the eyeball were checked every 10 Mts. till all the movements became normal again. In those cases where curare was injected intravenously movements were checked every 5 mts. for 20 mts. and then every 10 mts. till they became normal. Motor block was graded on a percentage basis applying Giffords[2] system, counting 20% for each rectus paralysed and 10% for each oblique paralysed.

(3) Corneal sensitivity was tested by means of a cotton wool wisp every 10 mts. till the normal sensitivity was regained. Since while taking the initial tension 1-2 drops of 1% Anethaine sol. was put in both the eyes, subsequent testing of corneal sensitivity was done by comparing how much longer the corneal anesthesia persisted in the test eye in which Retrobulbar injection was given, than in the fellow eye which had had only 1-2 drops of anethaine sol.

(4) Size of pupil was measured in mm. by comparative method with the pupillometer on the Theodore Hamblin Mortun's ophthalmoscope, every 10 mts. till the original size was regained.

RESULTS

Normal Cases

TENSION

Drug Injected	No. of cases	Average % fall in tesion	Time of greatest fall in tension	Average duration of hypotensive effect.
1—Normal Saline	5	Negligible	—	—
2—Novocaine	5	27.5	Between 5-10 Mts.	40 Mts.
3—Nov.-Adr.	5	34.3	-do-	58 Mts.
4—Nov.-Adr.-Hyal.	5	38.5	-do-	62 Mts.
5—Adr. with Saline	5	10	-do-	19 Mts.
6—Hyal.	5	Negligible	—	—
7—Xyl.	5	32.5	Between 5-10 Mts.	62 Mts.
8—Xyl.-Epi	5	38.7	-do-	94 Mts.
9—Curare	5	21.1	After 5 Mts.	26 Mts.
		Average % Rise in Intension	Time of greatest rise in tension	Average duration of Hypertensive effect.
10—Priscol	2	22.5	After 5 Mts.	30 Mts.

Muscle Paralysis

Drug injected	No. of cases	Average % of Muscle Paralysis	Time of maximum muscle paralysis	Average duration of muscle paralysis.
1—Normal Saline	5	0	—	—
2—Novocaine	5	67.0	After 10 Mts.-4 cases After 30 Mts.-1 cases	64 Mts.
3—Nov-Adr.	5	82.0	After 10 Mts.	148 Mts.
4—Nov-Adr-Hyal.	5	84.0	-do-	114 Mts.
5—Adr. With Saline	5	0	—	—
6—Hyal.	5	0	—	—
7—Xyl.	5	47.0	After 10 Mts.-3 cases After 20 Mts.-2 cases	138 Mts.
8—Xyl.-Epi.	5	63.0	After 10 Mts.-3 cases After 30 Mts.-2 cases	200 Mts.
9—Curare.	5	87.0	After 5 Mts.-	28 Mts.
10—Priscol.	2	0	—	—

Thus we see that an effective motor block of 60 % or over was obtained in 20 out of 25 cases *i. e.*, in 80% cases in which an anesthetic sol. was used for the Retrobulbar injection.

Average fall in tension with a muscle paralysis from 30 to 60% was 33.6% and with a muscle paralysis from 60 to 100% was 35%. This shows that there was no co-relation between the % of muscle paralysis and the % of fall in tension.

Corneal Sensitivity and Size of Pupil

Drug Injected	CORNEAL SENSITIVITY			PUPIL	
	No. of Cases	Corneal Anesthesia	Average duration of Corneal Anesthesia	A verage Mydriasis	Averag duration of mydriassis
1—Normal Saline		—	—	0	—
2—Novocaine	5	Present	64 Ms.	1.4 m.m.	86 Mts.
3—Nov-Adr.	5	-do-	134 Mtts.	1.4 m.m.	148 Mts.
4—Nov-Adr-Hyal.	5	-do-	110 Mts.	1.7 m.m.	116 Mts.
5—Adr. with Saline	5	—	—	0	—
6—Hyal.	5	—	—	0	—
7—Xyl.	5	Present	122 Mts.	1.7 m.m.	146 Mts.
8—Xyl.-Epi.	5	-do-	174 Mts.	1.8 m.m.	204 Mts.
9—Curare.	5	—	—	0	—
10—Priscol	5	—	—	0	—
	2				

Glaucoma Cases

TENSION

Type Glaucoma	No. of cases	Average % fall in tension	Time of greatest fall in tension	Avrage duration of Hypotensive effect.
Acute Glaucoma	5	39.2	Between 5-10 Mts. 4 case After 20 Mts.	144 Mts.
Chr. Congestive glaucoma	5	28.2	1 Case Between 5-10 Mts.	60 Mts.
Chr. Simple Glaucoma	5	23.5	Between 5-10 Mts.	56 Mts.

Muscle Paralysis

Type of Glaucoma	No. of cases	Average % of Muscle paralysis	Time of maximum paralysis	Average duration of paralysis.
Acute Glaucoma	5	98.0	After 10 Mts.	204 Mts.
Chr. Congestive glaucoma	5	69.0	-do-	148 Mts.
Chr. Simple glaucoma	5	57.0	-do-	100 Mts.

Corneal Sensitivity and Size of Pupil

Type of Glaucoma	No. of cases	Average duration of corneal anesthesia	Average Mydriasis	Average duration of Mydriasis.
Acute Glaucoma	5	190 Mts.	0.7 m.m.	212 Mts.
Chr. congestive Glaucoma	5	130 Mts.	0.8 m.m.	156 Mts.
Chr. simple Glaucoma	5	96 Mts.	1.0 m.m.	116 Mts.

DISCUSSION

It is evident from the results obtained in this study that retrobulbar injection of an anesthetic solution is effective in reducing the intraocular tension in all normal cases and most of the cases of glaucoma.

Normal Series

In the control cases where only Isotonic saline was injected, no marked change in the intraocular tension was recorded. The slight amount of lowering of intraocular tension which was noted might have been due to the seepage of aqueous by the weight of the tonometer while the tension was being taken every 5 mts.

Novocaine alone was effective in lowering the intraocular tension, but the addition of Adrenaline enhanced its effect and the addition of Adrenaline-hyaluronidase had still greater effect.

The greater fall in tension noted by the addition of Adrenaline might have been due to its vasoconstricting action on the arteries entering the globe producing a volumetric change within the globe and at the same time delaying the absorption of the anesthetic solution. When injected alone, Adrenaline produced only slight transitory fall in intraocular tension. The volumetric change being readily compensated by the safety-valve machanism of the exit channels.

Hyaluronidase enhances the effect of Novocaine-adrenaline solution on account of its spreading action, thus making an injection which is wide of the mark, still effective. Given alone it did'nt cause any significant fall in tension.

This shows that neither Hyaluronidase nor Adrenaline can be held responsible for this fall in tension. And so it is the anesthetic solution itself which is mainly responsible for this hypotensive effect.

Now how does anesthetic solution produce this hypotensive effect ?

The relaxation of extraocular muscles may have some influence on reducing the tension. In those cases where curare was injected intravenously, a definite fall of about 20% was noted. This could harldy be due to any thing else than paralysis of extraocular muscles. This shows that the tone of extraocular muscles is responsible for maintaining about 20% of the normal intraocular tension, and it can be separated from the total ocular tension by intravenous injection of curare or Retrobulbar injection of anesthetic solution which relaxes the extraocular muscles more or less completely.

But as the percentage fall in tension noted after Retrobulbar injection of anesthetic solution was greater than 20%, muscle paralysis alone, can not explain it. Also in our series no co-relation was found between the percentage of muscle paralysis and the percentage of fall in tension. The average percentage fall of tension with curare was only 20.1% while with Novocaine it was 27.6%, in-inspite of the fact that the average percentage of muscle paralysis with curare was 87% and with Novocaine only 67%. It has also been noted that the tension comes back to its original level much earlier than the time when the movements of the eyeball become normal.

All these findings point out to the fact that muscle paralysis alone can not be held completely responsible for the fall in tension but is only one of the contributing factors. Besides muscle paralysis there is some other factor.

Applying the hypothesis of Schmerl and Steinberg[6] in human beings, it can be presumed that Novocaine or any other anesthetic agent when injected Retrobulbarly blocks the conduction of Parasympathetic impulses, which are responsible for vasodilatation with a consequent rise in intraocular tension, through the ciliary ganglion. Thus the impulses passing through the superior cervical ganglion get the upper hand and cause vasoconstriction leading to fall in tension. But if it is so then the duration of fall in tension should be almost equal to the duration of muscle paralysis, corneal anesthesia, and mydriasis. But in the present study muscle paralysis, corneal anesthesia and mydriasis lasted almost for the same length of time which was much longer then the time when the tension came back to its original level. This is probably due to the local compensatory response by which the tension soon regains its original level. As soon as the tension falls due to the retrobulbar anesthesia, the venous pressure just inside the sclera also falls and thus the fall between this point and the episcleral veins becomes less and drainage is damped down, leeding to rise in tension till the original level is regained.

At present this is not much more than a working hypothesis but it seems to apply at least to normal cases.

Glaucoma Series

After retrobulbar anesthesia a definite fall in intraocular tension was recorded in all except two cases, one of Chr. simple glaucoma and another of Chr. congestive glaucoma. Like normal cases no co-relation was found between the percentage of muscle paralysis and the percentage of fall in tension, and the effect on extraocular muscles, corneal sensitivity, and size of pupil lasted almost for the same length of time which was much longer than the time when the tension came back to its original level. But in Chr. simple and Chr. congestive glaucoma cases the average percentage of lowering of intraocular tension was less as compared to normal cases. This according to Giff[2] must be due to a continued rise in the base pressure in these cases, and the two eyes which didn't show a significant fall in intraocular tension after retrobulbar anesthesia had probably lost their tension lowering capasity, the base pressure being elevated to a point equal to the initial pressure.

CONCLUSIONS

NORMAL CASES

1. Retrobulbar injection of an anesthetic solution produces a definite fall in intraocular tension.

2. The Hypotensive effect starts within 5 Mts. and is maximum between 5-10 Mts. after the injection.

3. The effect on tension lasts for a much shorter time than the effect on extraocular muscles, corneal sensitivity and size of pupil.

4. Out of all the drugs used, Novocaine-adrenaline-hyaluronidase and xylocaine-epinephrine solutions produce the greatest fall in tension. And the effect of Xylocaine-epinephrine lasts for the greatest length of time.

5. Hyaluronidase and probably Adrenaline also act indirectly by enhancing the effect of the anesthetic agent.

6. Muscle paralysis produced by retrobulbar anesthesia has got some influence on lowering of intraocular tension but is not completely responsible for the fall in intraocular tension.

7. Blocking of parasympathetic impulses through the ciliary ganglion by the anesthetic agent is probably another contributing factor.

GLAUCOMA CASES

In Chr. simple and Chr. congestive glaucoma cases the average fall in Intraocular tension after retrobulbar anesthesia is less than in normal cases and in some cases the base pressure is elevated to such a degree as to produce anatomic changes and there is no fall intension at all.

SUMMARY

A clinical study of the effect of retrobulbar anesthesia on intraocular tension was carried out in normal and glaucomatous cases.. In normal cases different drugs and combination of drugs were used for retrobulbar injection and

curare was used intravenously. In glaucoma cases only a combination of Novocaine-Adrenaline was used for retrobulbar injection. The effect of these drugs on intraocular tension, extraocular muscles, corneal sensitivity, and size of pupil was noted. It has been found out that novocaine-Adrenaline-Hyaluronidase and Xylocaine-Epinephrine solutions produce the greatest fall in tension. The effect of Xylocaine-Epinephrine solution lasts for the greatest length of time. Muscle paralysis is only one of the contributing factors responsible for the fall in Intraocular tension, blocking of the parasympathetic impulses through the ciliary ganglion by the anesthetic agent is probably another contributing factor.

REFERENCES

1. Elschnig, A. : *Arch. Augenh*, **98** : 300, 1927
2. Gifford, H. (Jr.) : A study of the effect of retrobulbar anesthesia on the ocular tension and vitreous pressure. *Am. J. Ophth.*, **32** : 1359, 1949.
3. Syndacker, D., Dentsch, W.E. and Bayard, W. L. : Various anesthetic agents used in retrobulbar injection, A. M. A. *Arch. Ophth.*, **51** : 473, 1954.
4. Greaves, D. P. : The effect of retrobulbar anesthesis on intraocular pressure. *Tr. Ophth. Soc.*, U. K. **75** : 121-135, 1955.
5. Atkinson, W. S. : Local anesthesia in Ophthalmology, *Am. J. Ophth.*, **31** : 1607, 1948.
6. Schmerl, E. and Steinberg, B. : Role of Ciliary and Superior Cervical ganglia in ocular tension *Am. J. Ophth.*, **32** : 947, July 1959.

COMPARATIVE STUDIES ON THE DIGESTIVE SYSTEM OF SOME INSECTS UNDER FED AND STARVED CONDITIONS*

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SUMMARY

Blatella humbertiana **Sauss**

1. The structure of the mouth-parts, their pigmentation, cuticularization and arrangement have been described.

2. It has been shown that the number of teeth of the right and left mandibles are different. The adductor muscle of the mandible is more developed than the abductor and the apodeme consists only of one plate.

3. There is a club-shaped ridge at the base of the galea. The glossae are symmetrically arranged and are equal in size.

4. The origin, direction and insertion of muscles of all regions of the mouth-parts have been described in detail.

5. The alimentary canal is longer than the whole length of the insect. The fore-gut is the longest part of the alimentary canal and it extends up to the third abdominal segment.

6. The oesophageal valve is well developed. At the anterior end of the valve the free border of the intima is provided with long backwardly pointing hairs which act as a sieve.

7. The peritrophic membrane extends from the anterior end to the posterior end of the mid-gut. It is of lameller type and is secreted by a group of cells at the junction of the fore-gut with mid-gut. In the starved insects the peritrophic membrane is much folded where as in fed insects it is much extended.

8. The mid-gut epithelium of starved and fed insects differ markedly in their histological characters.

9. The contents of the epithelial cells of the mid-gut enter into the lumen by (i) the discharge of the cell contents which is collected in a bulb at the free end, (ii) squeezing out of the contents of the epithelial cells, (iii) discharge of highly pigmented large particles and (iv) delamination of portions of epithelium.

10. The pyloric valve is absent. The ileum is very narrow and its musculature is very thick which acts as a sphincter.

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11. The colon is large and presumably act as reservoir for storage of food and the rectum is provided with six rectal pads.

12. In a starved insect majority of the epithelial cells are in the resting stage and only 7% show secretory activity.

13. An interval of one hour after feeding shows a sudden increase in the number of secretory cells *i.e.*, from 7%-60%.

14. The secretory activity reaches its peak after an interval of two hours after feeding when 90.5% of epithelial cells exhibit secretory activity.

15. Three hours after feeding the secretory cells decrease form 90.5% to 39%.

Labidura Bengalensis DOHRN

16. The structure of the mouth-parts, their pigmentation, culticularization and arrangement have been described.

17. There is no asymmetry in the number and arrangement of incisors of the right and left mandibles but there is a pronounced difference in the molar area of the two mandibles. The molar region of the right mandible is very thick and strongly sclerotized whereas that of the left mandible is thin and weakly sclerotized with its inner mergin fringed with stiff, short bristles.

18. From the dorsal surface of the cardo a prominent hook-shaped apodeme is given off which gives insertion to the promotor muscles. The cardo is strengthened by an internal ridge which is not at all indicated externally.

19. The stipes is composed of four pieces (i) juxtastipes (ii) basistipes (iii) palpifer (iv) basilacinia.

20. Glossa is absent. The labium is attached to the head capsule by two knowb-like process arising at the base of the submentum.

21. At the posterior end of the submentum there is a small sclerite, the gular.

22. The hypopharynx is a bag-like lobe with two small lateral wings.

23. The labrum has two pairs of extrinsic and two pairs of intrinsic muscles.

24. The mandibles has two extrinsic muscles.

25. The maxilla has six extrinsic muscles and seven intrinsic muscles.

26. The promotor muscle is made up of only one bundle.

27. The adductor of the stipes is not inserted on any ridge but it is inserted on the outer margin of the juxtastipes.

28. The stipital flexor is the lacinia is composed of only one bundle.

29. Separate levator and depressor muscles are absent but the stipital muscle of the maxillary palp combines in itself both the levator and depressor functions.

30. There are two extrinsic and eight intrinsic muscles in the labium.

31. The anterior retractor of the prementum originate from the lateral angles of the postoccipital ridge and not from the tentorial arms.

32. There is only a single pair of muscles associated with the salivery cup.

33. Two pairs of muscles are associated with the hypopharynx.

34. The alimentary canal is slightly longer than the length of the body.

35. The fore-gut is the longest of the three divisions of the alimentary canal and the mid-gut is the shortest.

36. In the pharynx the intima and epithelial layer are thrown into six to eight irregular longitudinal folds of which the one at the dorsal region is the largest. The intima is very thick and its inner surface which is covered with bristles is thrown into irregular grooves and ridges.

37. In the oesophagus the intima, which is covered with several rows of hairs and the epithelium are thrown into six prominent longitudinal folds.

38. In the crop, the intima, which is devoid of hairs, and the epithelium are thrown into indefinite number of folds. The size and number of the folds are not constant through out the length of the crop.

39. From the posterior region of the crop there arise a number of oblique muscles from the outer surface of the intima which extend up to the mid-gut wall.

40. The gizzard is well developed and its structure is very complicated. The intima and epithelial layer are thrown into six longitudinal folds. At the terminal end of the fore-gut the six longitudinal folds hang down as six fingers. The intima is very thick and its inner surface is broken up into irregular scale-like sculpturings with their margins fringed with stiff, long hairs. In the posterior region the intima is devoid of hairs.

41. The musculature of the gizzard is powerfully developed and is complicated. From outside inwards the following succession of muscles can be observed—circular muscles, longitudinal muscles, intrinsic muscles, oblique muscles, intrinsic longitudinal muscles and intrinsic oblique muscles of the folds.

42. There is well developed oesophageal valve.

43. There are two girdles at the anterior end of the mid-gut.

44. Correlated to the two anterior folds of the mid-gut there are two peritrophic membranes; one inner, homogenious, thin, cylindrical sheath which covers the food column and another external which is laminated.

45. The inner peritrophic membrane is secreted by the epithelial cells of the anterior girdle. Though the epithelial cells of the second girdle are the main source of the outer peritrophic membrane it is supplimented by several layers of membrane secreted by the epithelial cells throughout the whole length of the vetriculus.

46. Both merocrine and holocrine mode of secretion is observed.

47. The contents of the epithelial cells enter into the lumen in the following ways:— (a) vesicle formation at the striated border (b) liberation of secretory

granules (c) liberation of secretory globules (d) liberation of nuclei (e) delamination of epithelial cells (f) bouquet formation of the secretory cells.

48. At the junction of the mid-gut and hind-gut there are 32 malpighian tubules which are arranged in four bundles.

49. The hind-gut consists of ileum, colon and recturm.

50. The pyloric valve is not very well developed. A substitute structure is present at the posterior region of the ileum, there the circular musculature is strongly developed and acts as a sphincter; the longitudinal folds are very tall and almost extend up to the centre of the lumen; the intima bears stiff, backwardly pointed bristles.

51. In the rectum there are six rectal pads and it is furnished with a rich supply of tracheae.

52. In a starved insect the cytoplasm of the mid-gut epithelium is sparsely granular and the nidi are very small. Only 17% of the epithelial cells exhibit secretory activity.

53. After one hour of feeding the secretory cells increase from 17% to 52%. The cytoplasm of the cells is richly granular and it picks up a deep stain. The nidi at the anterior region of the mid-gut are large and each of them consists of 10 to 20 nuclei.

54. Two hours after feeding the secretory cells increase from 52% to 76%.

55. The secretory activity reaches its maximum after three hours of feeding when about 82% of cells exhibit secretory activity.

56. There is a pair of labial glands.

Epilachna Vigntioptocuntcata FABRS.

57. The mouth-parts of *Epilachna vigintioctopunctata* are of biting chewing type. The structure of the mouth-parts, their scleritization and musculature have been described.

58. There is no asymmetry in the number and arrangement of the incisors and molars of the right and left mandibles.

59. The cardo bears three apodemes; two of them are directed mesially and the third outwards, which give insertion to the extrinsic muscles of the maxilla. The stipes consists of three sclerites. There is a prominent feebly chitinized lobe at the outer side of the lacinia.

60. The labium is a very simple structure; separate glossa and paraglossa are absent.

61. The hypopharynx is a hollow bag-like structure. At about its mid-length there is a prominent constriction which divides the hypopharynx into an anterior membranous flap and a posterior chitinized portion. There is a forked suspensorium.

62. The labrum has only a pair of intrinsic muscles and two pairs of extrinsic muscles.

63. There are two extrinsic muscles associated with the mandibles.

64. In each maxilla there are four intrinsic and five extrinsic muscles. Of the five extrinsic muscles, three are associated with the cardo and two with stipes. A flexor muscle is inserted on the lacinia. Separate levator and depressor muscles are absent. But there is a stipital muscle which combines in itself both the levator and depressor muscles described in other insects.

65. In the labium there are only two intrinsic muscles. Extrinsic muscles are absent.

66. The hypopharynx is provided with only a pair of muscles.

67. The alimentary canal consists of the fore-gut, mid-gut and hindgut. It is highly convoluted and is about three times the length of the body. The mid-gut is the longest portion and the fore-gut shortest.

68. The fore-gut consists of pharynx oesophagus, crop and oesophageal valve. Gizzard is absent.

69. Hepatic caeca are absent.

70. The mid-gut can be differentiated into two portions—an almost straight, wide anterior portion (proximal lobe) and a narrow, coiled distal part (distal loop).

71. There are four malpighian tubules.

72. The hind-gut consists of ileum, colon and rectum. The colon is surrounded by a peritonial sheath, the space thus enclosed is pierced by the blind ends of the malpighian tubules.

73. Both holocrine and merocrine modes of secretion is observed and the contents of the epithelial cells enter the lumen (i) as non-nucleated vesicle (ii) as delamination of portions or whole of the gut epithelial cells (iii) as individual cells squezed out entirely into the lumen and (iv) as streems of nuclei.

74. In a starved insect the mid-gut epithelial cells shrivels up and many of them are without nuclei. About 90% of the cells are found to be in the resting stage.

75. After an hour of feeding the epithelial cells of the mid-gut become taller and the secretory cells rise from 9% to about 79%.

76. After two hours of feeding the secretory activity reaches at its peak. About 98% of cells exhibit secretory activity.

77. After three hours of feeding the number of secretory cells decreses. About 14% of the cells were found to be in the resting stage.

Musca nebulo WIED

78. The mouth-parts of *Musca nebulo* are enormously modified, and they comprise an eractile organ, the proboscis. The proboscis consists of proximal rostrum, middle houstellum and terminal labella or oral disc.

79. The most important structure in the rostrum is the fulcrum.

80. The anterior wall of the houstellum is made by the labrum-epipharynx

and the posterior wall by the mentum.

81. The oral disc or labella consists of two lobes whose inner surface are traversed by pseudotrachea.

82. There are thirteen muscles associated with the mouth-parts, of which four are extrinsic and nine are intrinsic.

83. The alimentary canal consists of the fore-gut, the mid-gut and the hind-gut. The mid-gut is the longest part of the alimentary canal and it is coiled several times.

84. The fore-gut consists of the pharynx, the oesophagus, the crop and the oesophageal valve. The oesophagus gives rise to a duct which leads to the bilobed sac-like crop.

85. The oesophageal valve is well developed and it is telescoped into the cardia, an enlarged anterior most part of the mid-gut

86. The laminated peritrophic membrane is secreted mainly by the epithelial cells of the anterior girdle, but other epithelial cells of the mid-gut also take part in its formation.

87. Regenerative cells are very sparse.

88. Both merocrine and holocrine modes of secretion are observed. The contents of the epithelial cells enter the lumen as (i) non-nucleated vesicles (ii) as secretory globules (iii) as secretory granulars squeezed out by the epithelial cells and (iv) as delaminated parts of the epithelial cells.

89. The hind-gut consists of the ileum, colon and rectum.

90. The pyloric valve is very poorly developed.

91. There are two malpighian tubules.

92. The ileum is slightly telescoped into the colon and the junction between the two is marked by a constriction externally. The circular muscles at this region are very well developed.

93. In the rectum there are four rectal papillae which are visible externally as oval discs.

94. In a starved insect the mid-gut epithelial cells are short and flat and about 90% of the cells are found to be in the resting stage.

95. One hour after feeding the secretory cells increase from 10% to 60%.

96. The secretory activity is reached at its peak two hours after feeding when about 99.6% epithelial cells exhibit secretory activity.

97. After three hours of feeding the secretory cells decrease from 99.6% to 64%.

A CLINICAL STUDY OF THROMBOANGIITIS OBLITERANS (BUERGER'S DISEASE)

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Thromboangiitis Obliterans is one of the peripheral vascular disease, and effects man in prime of his youth, and gives him excruciating pain due to ulceration and gangrene, which creeps from one part of the body to other. Patient is not able to sleep in the night due to extreme pain of ulceration and gangrene, and mostly passes night sitting upright in bed, groaning and rubbing the affected member, and smokes cigarette after cigarette in a futile attempt to force the pain into the background of consciousness. Patient is afraid to move the affected part, and neglects work and even bathing more than his face and hands with fear to increase pain. Pain is so constant and severe that he does not take interest in his surroundings and even cannot enjoy food brought to him. Large amount of opiates are also not able to remove pain and gradually his morale is shattered and he begs for relief from pain even at the cost of amputation of leg. Unfortunately the condition is quite common. Voluminous literature has accumulated on the subject and various remedies have been suggested, but inspite of this no cure has been found out as yet, and patient continues to pass the rest of life in an atmosphere of frustration and melancholy and cruel fate has nothing left for him except pain and pathos. It is painful to watch the miserable plight of these young man, who on account of this physical disability are doomed to lead a crippled existance as a burden to themselves and their family.

A long list of factors, *e.g.*, sex, age, heredity, race, bacterial, toxic, viral tobacco etc. have been held as responsible for the causation of disease, is itself an indication that we are still ignorant about the exact etiology of the disease. The existing confusion has been responsible for our failure to find a cause for it. Indirect attempts to relieve pain, and in some cases check the progress of the disease, by restoring the neuro surgery, have met with partial success.

The fact remains that we are still in dark about the exact etiology of the disease. In a five-year study of cases of peripheral vascular diseases—its incidence has been found to be 47·8%, and it is this high preponderance of this disease, that stimulated us to undertake this investigation, with an attempt to solve this difficult problem of etiology and evaluate the results of various remedies used in the treatment. To establish this we conducted clinical study of the patient with particular emphasis on the natural history of the case and the relation of the episode to any specific factor. The routine and special investigations were done to establish the diagnosis of the case and to determine the line of treatment and proper evaluation of results.

The study is based on the clinical, histopathologic arteriographic pictures and other special methods of diagnosis, the results of sympathectomy and the various etiologic factors held to be responsible for the causation of the disease. Fifty five cases of Thromboangiitis Obliterans were admitted in S. N. Hospital, Agra from January 1951 to September 1956.

OBSERVATIONS

Incidence—There are not many published reports regarding incidence of the disease in various States in our country. Some in 1952 had reported it to be one in every 166 surgical admissions in the West Bengal Hospital, where as one in 1000 patients in Mayo Clinic. In the present series 1 in every 362 surgical admissions was a case of Thromboangitis obliterans. It is apparent that in this region also the disease is very common. It is also interesting to note that 47·8% of all the cases of peripheral vascular disease were found to be suffering from Thromboangiitis obliterans and, most of the cases belonged to Agra District itself.

Age and Sex—The average age in the cases reported by Buerger was 32 years and 5 months. In the present series the average age was 36 years and the youngest was 20 years and oldest 47 years of age. All the cases studied were males without exception.

Social Status—Majority of the patients were found to belong to poor class.

Occupation—Of the patient does not seem to be of any importance.

Heridity—In one case only brother also suffered from the same disease. There have not been enough cases reported or studied over two or more generations in family groups to permit one to arrive at any conclusion regarding the heridity nature of the disease.

Smoking—All the patients were found to be smokers and few cases were also addicted to alcohol and smoking *Ganja* and *charas*. The disease is found to be of greater severity in heavy smokers.

Symptoms—(1) Intermitent claudication 72·7% (2) Pain 87·2% (3) Blackness 72·7% (4) Ulceration 70·9% (5) Sensitivity to cold 58·1% (6) Muscular weakness 52·7% (7) Tingling 45·4% (8) Burning 50·9% (9) Numbness 58·1%.

Physical Findings—(1) Nail deformity 61·8% (2) Ulceration 70·9% (3) Gangrene 56·3% (4) Oedema 52·7% (5) Wasting 36·3% (6) Sensory Loss 40·0% (7) Glandular enlargement 25·4% (8) Thrombophlebitis 21·8%.

Involvement of the Extremity—(1) Upper extremity alone 4 cases (2) Lower extremity alone 54 cases (3) Both the lower extremities 14 cases (4) Both lower as well as upper extremity 3 cases (5) Upper extremity alone 1 case.

Investigations :

1. Urine—No abnormal constituent found.
2. Wassermann Reaction—Negative in 54 cases and doubtfully positive in one case.
3. Haematological (a) Total W.B.C., Total R. B. C. and Hb% were found to be within normal limits.
   (b) Bleeding coagulation time, Blood sugar, Blood cholesterol were found to be within normal limits.
   (c) Blood Culture was found to be sterile after 5 days incubation.
4. *Arteriography* done in 10 cases. Site of occlusion was found in (a) Femoral artery 7 cases (b) Popliteal artery 2 cases, (c) Anterior and Posterior Tibial artery 1 case (d) Radial and Ulnar artery 1 case.
5. *Oscillometry*—Oscillometric index varies widely in normal individuals. No significant change was noted after smoking in oscillometric index either in normal or cases suffering from Thromboangiitis obliterans. In normal individuals it has been found that the oscillometric swing at the calf level rises and falls in cases of Thromboangiitis obliterans after exercise. It has been noted that fairly accurate level of arterial block can be ascertained by oscillometry as later confirmed by arteriogram. This investigation is of some importance for assessing the prognosis of the case and also the extent to which collateral circulation has been established.
6. *Skin Temperature Studies.*—This investigation was carried out in a thermostatically controlled room (cold storage) and skin temperature gradients in normal and in cases of Thromboangiitis obliterans were found out. Reflex vasodilatation response were also found out in normal as well as cases of Thromboangiitis obliterans. Effect of smoking on skin temperature in normal and in patients of Buerger's disease were noted.

It has been noted that a limb which was pulseless and effected with severe claudication pain, showed a gradient which differed very little from the corresponding normal limb. The common belief that a limb with impaired circulation is necessarily colder than its fellow is also not always true and that it depends very greatly upon environmental temperature at the time of observation.

Occasionally the affected extremity gives higher figures when sepsis or gangrene is present. It is apparent that little information of prognostic value is gained from observations of the resting surface temperature of the limbs.

The ability of cutaneous vessels to dilate in response to reflex vasodilatation induced by limb immersion method has been found to give more useful information regarding the prognostic value of the case and if any benefit is to be obtained by sympathectomy. A definite fall is noted in normal as well as cases of Thromboangiitis obliterans after smoking.

HISTOLOGICAL STUDY

Vessels—In acute lesions the lumen was found to be occluded by thrombus which is organised and contains fibroblasts and endothelial cells.. Proliferation of endothelial cells with a few foci of lymphocytes are also seen. Medial coat shows, well preserved muscle fibres, but fibroblasts and dilated Capillaries with endothelial proliferation are found. In adventitia, extensive fibroblastic proliferation is well marked. Lymphocytes are found around vasa vasorum, which shows thick medial coat and proliferated intima.

In chronic lesions, canalization of the thrombus is seen, but rest of the thrombus retains its cellular organization, with cells of adult fibrous type. The thrombus is more fibrotic and less cellular. In some cases internal elastic lamina is found to be thickened. In medial coat, fibroblasts and vasa vasorum with endothelial lining are found. Adventitia shows fibroblasts and increased amount of fibrous tissue.

Ganglion—The ganglion removed were subjected to histological study and in one case only chronic inflammatory changes in the ganglion of lumbar chain were observed. The case was suffering from extensive gangrene of the leg and this interesting finding difficult to corelate had not been noted so far.

TREATMENT

Medical—Priscol was tried in a large number of cases but the results obtained have been disappointing. Its effects are purely transitory. No case obtained permanent relief by the use of this drug alone. This is probably due to the fact that patients come very late, when the gangrene is already established. Priscol and Depropanex have been found to give some relief from rest pain.

Macrabin in high doses has been found to give relief from rest pain also and its exact mechanism of action is not known.

Intravenous hypertonic saline solution was tried only in few cases but the results were disappointing.

SURGICAL SYMPATHECTOMY

In 55 cases, 34 cases (61·8%) underwent sympathectomy and in total 44 sympathectomies were performed. In 34 cases the procedure was unilateral and in 5 cases bilateral. Lumbar in 39 (58 6%) 21 on right and 18 left side ; 5 (11·3%) were cervicothoracic, 4 right side and 1 on left side.

The value derived from this operative procedure has been arbitarily classified as good or poor ; if relief of major symptoms (but not all) occured and amputation was not necessary for over a 2 year interval or longer, and poor, if symptom abatement failed to occur or loss of a part was necessitated.

Lumbar sympathectomy—Good 64·1% Poor 35·9%
Cervicothoracic —Good 40·0% Poor 60·0%

AMPUTATION

In 55 cases 28 cases (50·9%) underwent major amputation of either one limb or both lower limbs or in addition one upper limb. In total 37 major amputations were done at the following sites ; Thigh 43·2%, Leg 40·5%, Foot 8·1%, Arm 5·4%, Forearm 2·6%.

17 major amputations were necessary inspite of previous sympathectomy. In 8 cases both the lower limbs were amputated.

ETIOLOGY

Occupation—Increased incidence is not found among any of the various occupations. Brown Allen-Mahorner, are of similar opinion, that active versus sedantary workers suffer equally from the disease.

Tobacco—Maddock and Coller demonstrated a fall in the cutaneous temperature due to smoking. A similar fall has been noted in this series of cases. The investigation was not done with denicotinized cigarettes and no opinion can be given if the same effect can be observed by it.

It has been noted, that the more the number of Bidies or cigarettes smoked, earlier the symptoms appeared, and those who smoked more than 20-40 Bidies a day major amputations were necessary as sympathectomy performed was not able to check the progress of the disease. Those who smoked "Ganja or charas" in addition to smoking of tobacco, had to undergo multiple amputations in the course of the disease. Observations confirm the findings of Erb, Mayer, Allen and Barker and agree with statement of Silbert "whatever the underlying cause, prolonged smoking is the immediate causative factor of the disease, and if patient continues to smoke, the disease progresses inspite of vigorous treatment."

Infection—Horton and Dorsey cultured gram positive pleomorphic streptococci from acutely inflammed veins and suggest it to be etiologic factor. Our observations agree with Mayo Clinic workers, in a failure to grow any organism from blood culture.

Many investigators have suggested viral or fungal infection. It may be argued that most of the viral diseases are of acute onset with general manifestations, and effect both sexes equally, but thromboangiitis is a chronic disease and restricted to males only. Mayer, Naide and Thompson have suggested fungal infection by dermato-phytosis, but this theory again fails to explain the low incidence of thromboangiitis obliterans among all persons who have dermatophytosis, and occasional cases in which there is no evidence of such fungal infection. It also fails to explain the selective affinity to males only, and it has not been possible to either culture or identify it in histological sections.

Toxin producing spasm—Telford suggested some toxic factor producing Spasm of blood vessels. Spasm element is present which is abolished by sympathectomy and blocking the lumbar sympathetic ganglia by spinal Anaesthesia. It is suggested that this spasm may be due to some unknown endrocrine factor, which is aggravated by tobacco.

Altered blood chemistry—It is possible that altered blood chemistry may hasten the thrombosis, where lumen of the blood vessel is already narrowed by cushioning of intima and spasm of its walls.

Anatomical peculiarity of blood vessel and trauma—According to Boyd the arterial lesions in patients below 35 years of age are mostly due to primary popliteal thrombosis, and repeated trauma due to peculiar position and attachment of the femoral and popliteal vessels is attributed to be the cause of this primary popliteal thrombosis. This view is not substentiated by our observations, as the lesions though segmental, were multiple in nature and trauma alone cannot explain them. Besides histologically inflammatory changes were found in blood vessels and not pure thrombosis.

Mal Nutrition—Most of the cases belong to the poor class and were emaciated, under-nourished and looked much older than the age. Malnutrition may be one of the etiologic factors in the causation of the disease.

Stress Syndrone—Recently it has been suggested to be a part of general adaptation syndrone produced by stress and strain causing disturbances of the hormonal function of the anterior pitutary, hypothalamus and adrenal cortex and restoration of these defeciencies has led to the arrest of progress of the disease. This revised concept is interesting but requires further confirmation.

Psycho-sometic factors—Many patients present peculiar personality with a noticeable tendency to refuse to carry out in detail advice of physicians, and the data relavent to use of tobacco are of interest in this respect.

Finally in considering etiology of thromboangiitis obliterans, it may be possible that various agents which injure blood vessels may be at fault, and may provoke the same response, specially in those persons who have vulnerable blood vessels. Another possibility is that a combination of factors, and not a common etiologic factor may be responsible for the causation of the disease.

PRODUCTION OF PEPTIDE BOND IN AQUEOUS SOLUTION FROM AMINO ACIDS

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SUMMARY

The effect of exposure of amino acids with energy material under aseptic conditions, to sun light and artificial light (1000 watt Philips bulb) has been studied. The results were analysed chromatographically. It was noticed that not only ultra-violet component of day light is effective in the synthesis of peptides and bigger molecules from amino acids but exposure with a weak source of ultraviolet radiation can also effect the combination of such simple molecules to form compounds having peptide link. Similar solutions of amino acids kept in pyrex vessels, when exposed to artificial light showed only dipeptide formation. The solutions of amino acids kept under similar conditions in complete darkness do not result in any peptide bond formation. The mechanism of the formation of the products appears to depend on formation of free redicals as intermediates.

INTRODUCTION

The formation of peptide link in amino acid mixtures at high temperatures (150°-250°C) has been studied by Fox and co-workers (1). Formation of peptide link requires about 2000-4000 cals per gm mole depending upon the amino acids among which the links is established.

K. Bahadur (2) has shown that peptide link is formed in aqueous solution of certain amino acids in presence of sucrose used as energy material, when the mixture is exposed to sun light. The present authors have investigated the formation of peptide linkage in aqueous solutions of certain amino acids in presence of sucrose. All the vessels, apparatus used and results obtained are described in this paper.

EXPERIMENTAL

The solution of amino acids and sucrose were taken in Quartz and pyrex flasks separately. Control solutions were kept in similar flasks heavily wrapped in black cloth. All flasks were cotton plugged and the solutions were sterilised in an autoclave at 15 lb pressure for 30 minutes to ensure perfectly aseptic condition.. To be sure that there was no trace of any other amino acid and peptide as impurity in the solution at the beginning, a sample of each solution was tested chromatographically. All the amino acid solutions gave negative results. These solutions were incubated at 25° C for 24 hours and sterilised again. The following solutions were used:

Glycine (2%) and Sucrose (5%) solutions.
Glycine (2%), L-Leucine (2%) and Sucrose (5%) solution.
L-Leucine(2%) and sucrose (5%) solution
L-Glutamic acid (0.1%) and Sucrose 2% solution.
L-Glutamic acid (0.1%), L-Leucine (0. 1%) and Sucrose (2%) Solution

All these solutions of amino acids were examined for complete sterilisation at the beginning of the experiment and also after irradiation for certain period using aseptic Potato dextrose medium and incubating it for 48 hours at 25° C. At each step of analysis these solutions were found to remain in perfectly sterilised state. These solutions in Quartz and pyrex flasks were exposed to sunlight and separately in different sets of flasks to the light of a 1000 watt Philips bulb kept at a distance of two feet. In case of exposure with artificial light the tempetature remained between 20°-25°C.

The exposure was continued and the solution was periodically taken out in an inoculating chamber under aseptic condition and test for peptide formation was made by chromatographic technique. It was observed that after an exposure of 300 hours, the peptide formation was easily detectable. The exposures, however, were continued for larger periods in order to find if more than one peptide is formed and to find if it be possible to trace the course of reaction in the solutions (Table No. II). The analytical technique employed to test and indentify the formation of the product was similar to that used by Bahadur (2), Consden, Gordon and Martin (3), and others (4, 5, 6, 7, 8, 9, 10, 11). The authors used circular paper chromatography using specially constructed device enabling us to use 48 cm. diameter paper. The results obtained are given in Table No. 1.

The complex mixture of amino acids and peptides, thus produced, on analysis yielded more ninhydrin spots on paper chromatograms than could be accounted for reactants and expected peptides. The new spots are due to the formation of new amino acids and their peptides in presence of light. An aqueous solution of glycine and sucrose on irradiation for about 300 hours and subsequent analysis showed a new distinct spot running more slowly than glycine in butanol-acetic acid-water solvent. It was compared with glycyl-glycine and found identical with the synthetic peptide (This synthetic peptipe and other peptides used for comparision with the photo synthetic products were obtained from Nutritional Biochemicals Corporation Cleveland, Ohio). But on long exposure (800 hours) the solution showed more new spots, out of these two running more slowly than diglycine and two more rapidly than glycine. The spots which ran more slowly than diglycine were compared separately in butanol-acetic acid-water and phenol-water solutions with triglycine and tetraglycine and both were found to have the same Rf value. The peptide spots initially gave a yellow colour with ninhydrin and the colour turned purple on standing. The two spots running more rapidly than glycine were compared with other synthetic peptides and amino acids. Out of the two one was found to have the same Rf value as that of alanine. The other spot which moves in between glycine and alanine was compared with glycyl-alanine and found to have the same Rf value. It was observed that the rate of flow of glycyl peptides in phenol-water and pyridine-isoamyl alcohol mixture increased with increasing molecular weight. But the Rf value in butanol-acetic acid-water solvents decreased with increasing molecular weight.

The peptide spots were also compared with synthetic peptides using standard control solutions with or without sucrose. Strictly similar volumes of experimental and control solutions with or without sucrose of the same concentration were subjected to chromatographic analysis. Thus the effect of other products in solution on Rf of pepties was partly eliminated. At the same time the new spots were resolved by multiple development and separately by running two demensional chromatograms and the position of spots was located by observing the fluorescence with ultra-violet lamp. The respective peptide spot was extracted with water and compared with the synthetic peptide on a new paper chromatogram.

Besides, these new amino acids and peptides, the solution indicated the formation of norleucine, hydrazine, hydroxylamine, N-glycosides, and keto acids.

Glycine in the presence of L-leucine and sucrose, gave a new spot which moves in between glycine and L-leucine. The glycyl-L-leucine was run alongside of the spot and was indentical with the synthetic peptide. The new spot had the same Rf as glycyl-L-leucine. The formation of glycyl-L-leucine was confirmed by locating its position on paper chromatogram, extracting with water and comparing with synthetic glycyl-L-leucine and also by its hydrolysis and subsequent analysis on new paper chromatograms. Besides, a number of other spots were obtained when the exposure was continued. One of these was indentical with L-leucyl-L-leucine. This spot of L-leucyl-L-leucine moves rapidly than L-leucine in phenol-water and pyridine-isoamyl alcohol mixture. The complete identification of a number of other spots has not been achieved. However, the aqueous solution of glycine and leucine kept in quartz vessel, yielded a number of other faint spots. One of these was identical with diglycine.

The aqueous solution containing L-glutamic acid and sucrose showed two new spots moving more slowly than the acid itself. One of these running more slowly than glutamic acid runs with an Rf value as that of glutamyl-glutamic peptide. The spot moving more rapidly than glutamic acid was compared with other amino acids and peptides. It was identical with L-aminobutyric acid. Similarly, L-leucine showed the formation of L-leucyl-L-leucine.

The mixture containing L-glutamic acid and L-leucine and sucrose showed new spots corresponding to L-leucyl-glutamic acid running slower than L-leucine. One new spot ran in the same position as that obtained from the mixture containing L-glutamic acid and sucrose. A few other faint spots could not be identified due to incomplete separation. But on prolonged experiments two more distinct spots were obtained which move more rapidly than L-glutamic acid and found to have the same Rf as that of L-amino butyric acid and r-amino butyric acid. Few faint spots were corresponding to alanine and aspartic acid when compared with the synthetic acids.

After the prolonged exposure and experimentation the solutions of glycine, L-leucine and L-glutamic acid and their mixtures with sucrose were tested with aseptic Potato dextrose medium. It was incubated for 48 hours at 25° C. All these solutions were found under aseptic condition. Though no quantitative estimation of peptides could be done, the authors are trying now to provide additional evidence of peptide photosynthesis in aqueous solution from amino acids. All the amino acid solutions indicated the formation of N-glycosides, hydroxylamine, hydrazine, hydroxy and keto acids etc. These are under further investigation in our laboratories.

The aqueous solutions of certain amino acids, kept in quartz flasks, when exposed to sun light yielded a mixture of amino acids and peptides. But the amino acid solution kept in pyrex flasks showed only peptide spots

All the control solutions of amino acids used, kept in dark, were similarly tested for peptides. These solutions did not show any peptide spot on the paper chromatograms.

Table 1

Effect of exposure to sun light				Effect of exposure to bulb light	
Solution	Uncovered quartz flask	Uncovered pyrex flask	Quartz and pyrex flasks wrapped with black cloth	Uncovered pyrex flask	Pyrex flask wrapped with black cloth
Glycine solution	Glycine, Norleucine, Alanine, Diglycine, Triglycine, Tetraglycine, Glycylalanine; some unknowns.	Glycine, Diglycine,	Glycine.	Glycine, Diglycine.	Glycine.
Glycine & L-leucine Solution	Glycine, L-Leucine, Diglycine, Glycyl-L-leucine, L-leucyl-L-leucine; few faint spots.	Glycine, L-Leucine, Diglycine, Glycyl-L-leucine.	Glycine, L-Leucine.	Glycine, L-Leucine, Diglycine, Glycyl-L-leucine.	Glycine, L-Leucine.
L-Leucine solution	L-Leucine, L-Leucyl-L-leucine.	L-Leucine, Dileucine,	L-Leucine.	L-Leucine, Dileucine.	L-Leucine.
L-Glutamic acid solution	L-Glutamic acid, L-Glutamyl-L-glutamic acid, α-amino butyric acid, γ-amino butyric acid; few faint spots	L-Glutamic acid, Diglutamic acid.	L-Gultamic acid	L-Glutamic acid, Diglutamic acid.	L-Glutamic acid.
L-Glutamic acid and L-Leucine Solution	L-Glutamic acid, L-Leucine, L-Leucyl-L-glutamic acid, L-Leucyl-L-leucine; few faint spots	L-Glutamic acid, L-Leucine, L-Leucyl-L-glutamic acid, Di-leucine	L-Glutamic acid, L-Leucine.	L-Glutamic acid, L-Leucine, L-Leucyl-L-glutamic acid, Dileucine.	L-Glutamic acid, L-Leucine.

Table 2

The influence of period of irradiation on the nature and process of formation of new amino acids and peptides.

Reaction Time, hours	Colour of solution	Glycine solution	Leucine solution	Glutamic acid solution
1. 0- 50	Colourless	Glycine	L-Leucine	L-Glutamic acid
2. 50-100	Colourless	Glycine, Alanine, Faint peptide spot.	L-Leucine	L-Glutamic acid
3. 100-150	Colourless	Glycine, Alanine, Norleucine, Faint peptide spots.	L-Leucine	L-Glutamic acid α & γ–Amino butyric acid.
4. 150-200	Colourless	Glycine, Alanine, Norleucine, Faint peptide spots.	L-Leucine	L-Glutamic acid α & γ–Amino butyric acid.
5. 200-250	Colourless	Glycine, Alanine, Norleucine, Faint peptide spots.	L-Leucine	L-Glutamic acid α & γ–Amino butyric acid.
6. 250-300	Colourless	Glycine. Alanine, Norleucine, Diglycine, Glycyl-alanine.	L-Leucine Dileucine,	L-Glutamic acid α & γ–Amino butyric acid, Diglutamic acid.
7. 300-350	Colourless	Glycine, Alanine Norleucine, Diglycine,Glycyl-alanine.	L-Leucine, Dileucine.	L-Glutamic acid α & γ–Amino butyric acids, Diglutamic acid.
8. 350-400	Colourless	Glycine, Alanine Norleucine Diglycine, Glycyl-alanine.	L-Leucine, Dileucine,	L-Glutamic acid α & γ–Amino butyric acids, Diglutamic acid.
9. 400-450	Slightly Yellowish colour	Glycine, Alanine, Norleucine, Diglycine, Glycyl-alanine, Triglycine.	L-Leucine, Dileucine.	L-Glutamic acid α & γ–Amino butryic acids, Diglutamic acid.

Table 2 (*Contd.*)

Reaction Time, hours	Colour of solution	Glycine solution	Leucine solution	Glutamic acid solution
10. 450-500	Yellowish brown	Glycine, Alanine, Norleucine, Diglycine, Glycyl alanine, Triglycine.	L-Leucine, Dileucine.	L-Glutamic acid α & γ–Amino butyric acids, Diglutamic acid.
11. 500-550	Yellowish brown	Glycine, Alanine, Norleucine, Diglycine, Glycyl-alanine, Triglycine.	L-Leucine, Dileucine.	L-Glutamic acid α & γ–Amino butryic acid, Diglutamic acids.
12. 550-600	Yellowish brown	Glycine, Alanine, Norleucine, Diglycine, Glycylalanine, Triglycine, Tetraglycine.	L-Leucine, Dileucine.	L-Glutamic acid α & γ–Amino butyric acid, Diglutamic acids, few more spots.
13. 600	Yellowish brown	Glycine, Alanine, Norleucine, Diglycine, Glycyl-alanine, Triglycine, Tetraglycine.	L-Leucine, Dileucine, few more spots.	L-Glutamic acid α & γ–Amino butryic acid, Diglutamic acids, few more spots

DISCUSSION

The photolysis of certain amino acids has been investigated over the temperature range 20°–25°C in presence of light and atmospheric pressure under aseptic conditions. From the products of photolysis of glycine it appears probable that the reaction proceeds through the following free radical mechanism:—

$$\begin{aligned} H_2NCH_2COOH+{}_nh\nu &\rightarrow CH_2+NH_2+CO+OH && (1)\\ &\rightarrow CH_2+CO_2+H+NH_2 && (2)\\ &\rightarrow CH_3+CO_2+NH_2 && (3) \end{aligned}$$

In presence of water the photolysis of glycine can also take place as follows:—

$$\begin{aligned} HOH+{}_nh\nu &\rightarrow H+OH && (4)\\ &\rightarrow 2H+O && \\ H_2NCH_2COOH+H &\rightarrow H_2NCH_2COO+H_2 && (5)\\ H_2NCH_2COO &\rightarrow H_2N+CH_2+CO_2 && (6)\\ H_2NCH_2COO+H &\rightarrow CH_3+NH_2+CO_2 && (7)\\ H_2NCH_2COOH+H &\rightarrow CH_3+COOH+NH_2 && (8)\\ \overset{+}{H}_3NCH_2COO+H. &\rightarrow NH_3+CH_2+COOH && (9) \end{aligned}$$

$$\begin{array}{lcll}
H_2NCH_2COOH+H & \rightarrow & CH_3CO+OH+NH_2 & (10)\\
+ & & + & \\
H_3NCH_2COOH+OH & \rightarrow & H_3NCH_2COO+HOH & (11)\\
 & & + & \\
H_2NCH_2COOH+HOH & \rightarrow & H_3NCH_2COOH+OH & (12)\\
+ & & + \qquad\quad + & \\
H_3NCH_2COOH+HOH & \rightarrow & H_3NCH_2COO+H_3O & (13)
\end{array}$$

The species (H) may be the same or it may be different.

Methyl and methylene radicals can undergo recombination reaction, disproportionation and decomposition reactions to form gaseous products which will escape out from the solution:

$$\begin{array}{lcll}
2CH_3 & \rightarrow & C_2H_6 & (14)\\
CH_3+H & \rightarrow & CH_2+H_2 & (15)\\
 & \rightarrow & CH_4 & (16)\\
CH_3 & \rightarrow & CH+H_2 & (17)\\
CH_3+CH & \rightarrow & C_2H_4 & (18)\\
 & \rightarrow & CH_3CH & (19)\\
2CH_2 & \rightarrow & C_2H_4 & (20)\\
 & \rightarrow & CH_2CH_2 & (21)\\
CH_3+CH_2 & \rightarrow & CH_4+CH & (22)\\
 & \rightarrow & C_2H_5 & (23)\\
CH_3CH_2+OH & \rightarrow & CH_3CH+HOH & (24)\\
(CH_2)n & \rightarrow & (CH_2CH_2)n & (25)
\end{array}$$

Accepting the above photolytic decomposition of glycine, the following reactions may be proposed to explain the observed results such as formation of alanine and norleucine:—

$$\begin{array}{lcll}
CH_3CH+NH_2+COOH & \rightarrow & CH_3CH(NH_2)\ COOH & (26)\\
CH_2CH_2+NH_2+COOH & \rightarrow & CH_3CH(NH_2)\ COOH & (27)\\
6CH_2+NH_2+COOH & \rightarrow & CH_3(CH_2)_3CH(NH_2)COOH & (28)\\
H_2NCH_2COOH+CH_2 & \rightarrow & H_2NCH_2COO+CH_3 & (29)
\end{array}$$

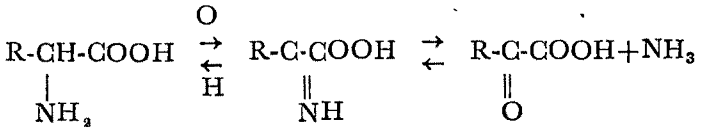
Similarly, other combinations can also explain the formation of acids such as pyruvic acid, oxalic acid etc:—

$$\begin{array}{lcll}
CH_3+CO & \rightarrow & CH_3CO & (30)\\
CH_3CO+COOH & \rightarrow & CH_3COCOOH & (31)\\
2COOH & \rightarrow & (COOH)_2 & (32)
\end{array}$$

Besides these, the formation of strong reducing agents such as hydrazine hydroxylamine, etc. can be explained as follows:

$$\begin{array}{lcll}
NH_2+NH_2 & \rightarrow & NH_2NH_2 & (33)\\
NH_2+OH & \rightarrow & NH_2OH & (34)\\
NH_2+H & \rightarrow & NH_3 & (35)
\end{array}$$

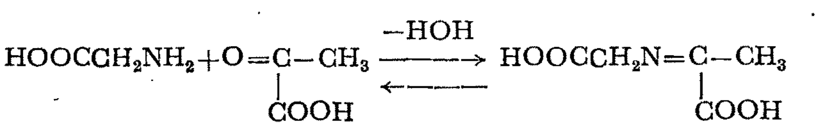
In presence of air one can as well suggest the photochamical oxidation of amino acids through ≺-Keto acids :—



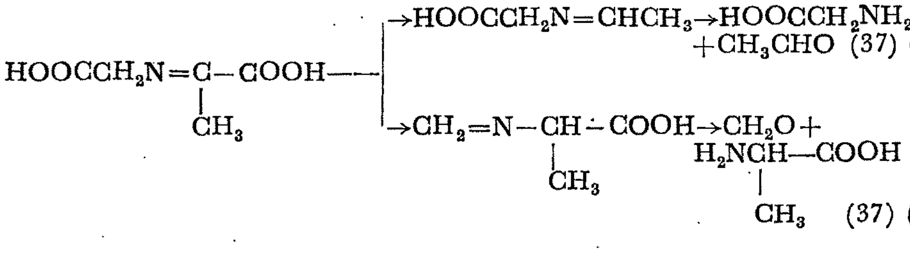
$$\underset{NH_2}{\text{R-CH}}\text{-COOH} \overset{O}{\underset{H}{\rightleftarrows}} \underset{NH}{\underset{\|}{\text{R-C}}}\text{-COOH} \rightleftarrows \underset{O}{\underset{\|}{\text{R-C}}}\text{-COOH}+NH_3 \quad (36)$$

The photolytic transformation of glycine into alanine, norleucine and their peptides, is attributed to splitting of bonds in stable molecules (steps 1-13) to produce reducing and oxidising agents, atoms, radicals and activated molecules. These atoms and radicals thus produced can undergo various reactions such as abstractions reaction (15, 11, 22, 24, 29) to produce a different molecular species and radicals, radical-radical recombination reactions to produce bigger radicals with or without disproportionation (18, 19, 20, 21, 25), recombination and disproportionation reactions (14, 16, 19, 26, 27, 30, 31) and decomposition reaction (17). Reactions 26, 27, and 28 explain the formation of alanine and norleucine respectively as observed chromatographically. Reactions 30, 31, 32, 33, 34, 35, 36 explain the formation of pyruvic acid, oxalic acid, hydrazine, hydroxylamine and ammonia. Oxalic acid, hydrazine etc. has been chromotagraphically detected. Some of the above compounds as hydroxylamine etc. have already been spectrally detected by Gurwitsch and co-workers (12) in glycine solution when exposed to sun light. Step 10 is similar to the photolysis of acetic acid in solution (13), which does involve methyl radicals. Neuberg (14) has shown the deamination of amino acids on exposure to sun light. The reaction is specific for ≺-amino groupings (15).

In this laboratory we have observed that ≺-Keto and ≺-hydroxy acids are among the products of prolonged photolytic deamination of amino acids. Reaction 30, 31, 36, explain the formation of pyruvic acid in aqueous solution of glycine. The presence of pyruvic acid was indicated chromatographically (16). Formation of Keto compounds from amino acids by various tissues have been studied by Heinsen (17) and Luciana Vantaggi-Cozzari and Giovanni Trampetti (18). ≺-Keto acids are useful intermediates especially for the synthesis of ≺-amino acids. Pyruvic acid formed at stage 31 most probably condenses with glycine in the solution to form methylene azomethine system.



$$HOOCCH_2NH_2+\underset{COOH}{\underset{|}{O=C}}-CH_3 \underset{\longleftarrow}{\xrightarrow{-HOH}} HOOCCH_2N=\underset{COOH}{\underset{|}{C}}-CH_3 \quad (37)$$



$$HOOCCH_2N=\underset{CH_3}{\underset{|}{C}}-COOH \to HOOCCH_2N=CHCH_3 \to HOOCCH_2NH_2 + CH_3CHO \quad (37)\ (a)$$

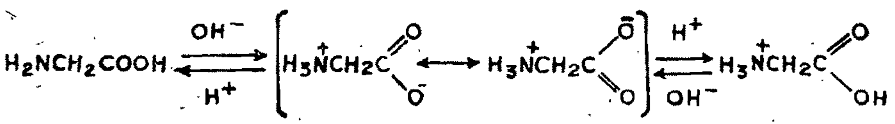
$$HOOCCH_2N=\underset{CH_3}{\underset{|}{C}}-COOH \to CH_2=N-\underset{CH_3}{\underset{|}{CH}}-COOH \to CH_2O + H_2N\underset{CH_3}{\underset{|}{CH}}\text{—}COOH \quad (37)\ (b)$$

Two methylene azomethines are assumed to result, of these, one hydrolyses to give back glycine and the aldelyde formed by the decarboxylation of the keto acid; the other decomposes to form alanine, derived from ketonic acid -by amination and reduction, and the aldehyde from the oxidative deamination and photodecarboxylation of the original amino acid.

The formation of ∝-ketoglutaric acid from L-glutamic acid was also detected by the method of Villano and Langella (19).

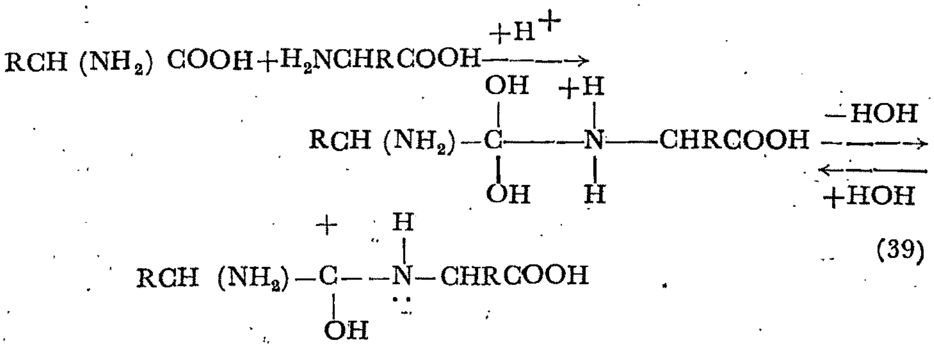
Reaction between ∝-keto acids and amino acids at high temperature has been studied by Herbst (20), Herbst and Engel (21) and Giri and coworkers (22).

The photosynthesis of diglycine, triglycine, tetraglycine and glycylalanine from glycine in solution in presence of light, is associated with condensation, dehydration and hydrogenation of active glycine molecules in the presence of proton. We knew that amino acids exists, in aqueous solution,. largely in the form of dipolar ions (23, 24) :



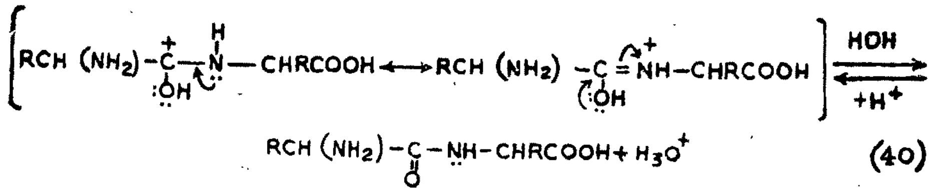
(38)

In aqueous solution and in presence of proton the proportionof uncharged groups are to some extent in equilibrium with positively charged groups. Thus in the presence of light and water they absorb more light than could be expected from dipolar ions. The activated molecules undergo some kind of combination by a chain mechanism to form bigger molecules having peptide links. The energy liberated by the photodecomposition of water and photooxidation of other molecules in solution can be stored in the form of electron-pair-bond along with light energy transferred to chemical part of photo-synthesis in presence of photosensitizers within the photosynthetic apparatus. Thus the energy in the synthesis of peptide link (2000-4000 Cal/gm mole) partly comes from the photodecomposition of water, amino acids and partly by the efficient transformation of light into chemical energy. There is, however, sucrose as energy source for the formation of peptide bonds in solution. The reaction appears to proceed through the following intermediates :



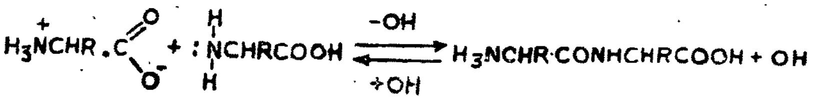
$$\mathrm{RCH\ (NH_2)\ COOH+H_2NCHRCOOH} \xrightarrow{+H^+} \mathrm{RCH\ (NH_2)}-\overset{\displaystyle OH}{\underset{\displaystyle OH}{\mathrm{C}}}-\overset{\displaystyle +H}{\underset{\displaystyle H}{\mathrm{N}}}-\mathrm{CHRCOOH} \underset{+HOH}{\overset{-HOH}{\rightleftharpoons}} \overset{+}{\mathrm{RCH}}\ \mathrm{(NH_2)}-\underset{\displaystyle OH}{\mathrm{C}}-\overset{\displaystyle H}{\underset{\cdot\cdot}{\mathrm{N}}}-\mathrm{CHRCOOH}$$

(39)

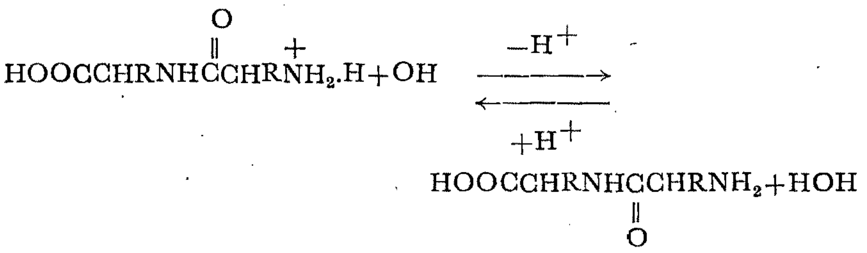


(40)

A large proportion of water may favour the hydrolysis of peptides but the proton catalysed polymerization may, however, be influenced by water. The polymerization of caprolactam is known to be influenced by traces of water (25). However, the polymerization may also be influenced by the carbon substituent. An attractive possibility of polymerization by step 41 and 42 is also significant :



(41)



$$\mathrm{HOOCCHRNH\overset{\overset{O}{\|}}{C}CHR\overset{+}{N}H_2.H+OH} \underset{+H^+}{\overset{-H^+}{\rightleftarrows}} \mathrm{HOOCCHRNH\underset{\underset{O}{\|}}{C}CHRNH_2+HOH} \quad (42)$$

The proton catalysed formation of peptide link probably involves electronic mechanism. From step 41, 42 it appears probable that polymerisation simply involves electron transfer from nitrogen atom to carbon atom of charged carboxyl group and simultaneous elimination of —OH (step 41). The strongly hydrogen bonding polar substituent or charged group can originate electrostatic fluctuations within the molecule and interact with the proton of the carboxyl group partly through the solvent and partly through the cavity of the molecule itself. However, polymerization of glycine into polyglycines, and, similar polymerizations of glutamic acid and leucine are the consequences both of electrostatic effects and of strong interactions between charged ammonium group and peptide linkage and water molecule.

One can as well suggest a simple free radical mechanism for the formation of peptide in aqueous solution :

$$\mathrm{2HOH \longrightarrow 4H+O_2}$$
$$\mathrm{H_2NCHRCOOH \longrightarrow H_2NCHRCO+OH} \qquad (43)$$
$$\mathrm{H_2NCHRCOOH+H \longrightarrow H_2NCHRCOO+H_2} \qquad (44)$$
$$\mathrm{OOCCHRNH_2+OH \rightarrow OOCCHRNH+HOH} \qquad (45)$$
$$\mathrm{HOH+H \rightarrow H_2+OH} \qquad (46)$$
$$\mathrm{\rightarrow H_3O^+} \qquad (47)$$

$$H_2NCHRCO + NHCHRCOO \rightarrow H_2NCHRCONHCHRCOO \quad (48)$$

$$H_2NCHRCONHRCOO + H_3O^+ \rightarrow H_2NCHRCONHRCHRCOOH + HOH \quad (49)$$

$$H_2NCHRCONHCHRCOOH \rightarrow H_2NCHRCONHCHRCO + OH \quad (50)$$

$$H_2NCHRCONHCHRCO + NHCHRCOO \rightarrow \text{Polymer (gly)} \quad (51)$$

Reactions 48 and 51 are the recombination reactions and explain the formation of polyglycines, dileucine and diglutamic acids etc., from glycine, leucine and glutamic acid, respectively, in solution. Reactions 45, 46, 49, are the abstraction reactions. The new species formed at stage 48 can immediately drag proton from H_3O^+ or unite with the proton obtained by the photolysis of water to form a peptide molecule. The peptide molecule thus formed can undergo photolysis to form a bigger radical which can homopolymerise or unite with the free radical formed at stage 45 to form a polymer. The repetition of this process can gradually cause the synthesis of bigger and bigger protein like molecules.

If a protein like compound is thus obtained, then it is not difficult to explain many combinations of amino acids and peptides we encounter in nature by the intervention of oxidase, reductase, dehydrogenase and special ring closing enzymes.

Accepting the above free radical mechanism, the formation of peptides from glycine, leucine and glutamic acid, and from their mixtures in water can be explained as follows :

Glycine in solution homopolymerises to form polyglycines:

$$H_2NCH_2COOH + H_2NCH_2COOH \underset{+HOH}{\overset{-HOH}{\rightleftarrows}} \text{Poly (gly, gly)} \quad (52)$$

Glycine molecules can also combine with alanine molecules synthesized photochemically to form glycyl-alanine :

$$H_2NCH_2COOH + H_2NCH(CH_3)COOH \underset{+HOH}{\overset{-HOH}{\rightleftarrows}} H_2NCH_2CONHCH(CH_3)COOH \quad (53)$$

Glycine in the presence of leucine gives dileucine, glycyl-L-leucine :

$$H_2NCH_2COOH + H_2NCH(COOH)CH_2CH(CH_3)_2 \underset{+HOH}{\overset{-HOH}{\rightleftarrows}} \text{Poly (gly, leu)} \quad (54)$$

L-Leucine alone gives leucyl L-leucine :

$$2(CH_3)_2CHCH_2CH(NH_2)COOH \underset{+HOH}{\overset{-HOH}{\rightleftarrows}} \text{Polymer (leu, leu)} \qquad (55)$$

Glutamic acid in aqueous solution can undergo photodecarboxylation to form α-- and γ— amino butryc acids (56) (a), (56) (b)

$$HOOCCH_2CH(NH_2)COOH — \left| \begin{array}{ll} \rightarrow CH_3CH_2CH(NH_2)COOH & (56\ a) \\ \rightarrow HOOCCH_2CH_2CH_2NH_2 & (56\ b) \end{array} \right.$$

Glutamic acid gives glutamyl-glutamate :

$$\begin{array}{r} 2HOOCCH_2CH_2CH(NH_2) \\ COOH \end{array} \underset{+HOH}{\overset{-HOH}{\rightleftarrows}} \begin{array}{l} HOOCCH_2CH_2CH(NH_2)- \\ CONHCH(COOH)(CH_2)_2 \\ \qquad\qquad\qquad COOH \end{array}$$

$$\text{or } HOOCCH(NH_2)CH_2CH_2CONHCH(COOH)CH_2CH_2COOH \qquad (57)$$

Similarly L-leucyl-L-glutamic acid was detected in an aqueous solution of glutamic acid and Leucine :

$$\begin{array}{l} (CH_3)_2CHCH_2CH(NH_2)COOH + \\ H_2NCH(COOH)CH_2CH_2COOH \end{array} \underset{+HOH}{\overset{-HOH}{\rightleftarrows}} \text{Polymer (glu, leu)} \qquad (58)$$

In studies of polymerisation of glycine, leucine and glutamic acid, when exposure was continued with regular interval between irradiation period and dark period, reaction mixture gradually developed yellow colour which finally changed to yellowish brown on keeping above six hundred hours out of day light under aseptic conditions. At the same time when the exposure was continued reaction mixtures yielded more and more ninhydrin positive peptide spots on paper chromatograms. It may be concluded that in the presence of continuous energy source, these amino acids can interact to form new reactants, polymers, and these products would in turn react to form macromolecular aggregates having peptide links. Such experiments suggest the process of formation of peptides form simple molecules and evolution of biochemical substances in water. In this way it becomes possible to understand the prebiological origin of protein on the earth.

CONCLUSION

From experiments described in this paper it appears probable that not only ultra violet component of day light is effective in the synthesis of peptides and bigger molecules from amino acids, but exposure with a weak source of ultra violet radiation (1000 watt. Phillips bulb) can cause the combination of preliminary units to form compounds having peptide links. At the same time keeping of aqueous solution of amino acids in complete darkness do not result in any peptide bond formation. It has also been observed that if similar solutions of certain amino acids with energy material are kept in pyrex vessels and after sterilization are exposed to artificial light, the reactions proceed only upto the stage of dipeptide formation. The mechanism of the formation of the products appears to depend on formation of free radicals as intermediates.

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REFERENCES

1. Fox, S. W. *et al* 1953, *Am. Naturalist,* **87,** 253-56; Fox and Middle brooke, M. 1954, *Federation Proc.,* **13,** 211; Fox, S. W. *et al* 1957, *Ann. N.* Y. *Acad. Sci.,* **69.** 328 *et seq.*
2. Bahadur, K. and Ranganayaki, S, 1958, Proc. Nat. Acad. Sci., **XXVII** (*A*), 292
3. Consden, R., Gordon, A. H. and Martin, A. J. P. 1944, *Biochem. J.,* **38,** 224; Consden, R., Gordon, A. H., and Martin, A. J. P., 1947, *Biochem. J.,* **41,** 590.
4. Toenniės, G., and Kolb, J. J., 1951, *J. Anal. Chem.,* **23,** 823.
5. Bull, H. B., Hahn, J. W., and Baptest V. H., 1949, *J. Am. Chem. Soc.,* **71,** 550.
6. Edman, P., 1945, *Ark. Kemi. Mineral., o. Geol.,* **22A,** 1.
7. Phillips, D. M. P., 1948, *Nature,* **161,** 53.
8. Porath, J. and Flodin, P., 1951, *Nature,* **168,** 203.
9. Giri, K. V. and Rao, N. A. N., 1952, *Nature,* **169,** 923.
10. Giri, K. V., Krishnamurthy, K. and Venkatasubramanian, T. A., 1952, *Current Sci.* (India), **21,** 44.
11. Woiwod, A. J., 1949, *J. gen. Microbiol.,* **3,** 312.
12. Gurwitsch, A. G. and Gurwitsch, A. A., 1958, *Enzymologia, Acta Biocatalytica* (Autoreproduction), **XX,** 1.
13. Clusius, K., and Schanzer, W., 1942, *Ber.,* **758,** 1795.
14. Neuberg, 1908, *Biochem. z.,* **13,** 305.
15. Lieben and Urban, 1931, *Biochem. Z.,* **239,** 250
16. Magasanik, B., and Umbarger, H. E., 1950, *J. Am. Chem. Soc.,* **72,** 2308-2309.
17. Heinsen, H. A. (Wald Krankenhaus, Zeven, Hannover, Ger.), 1950, *Z. ges. exptl. Med.,* **116,** 105-16; cf. *ibid,* 1942, **111,** 223. Heinsen, H. A., 1945, Z. ges. exptl. Med., **114,** 755-67;
18. Luciana Vantaggi-Cozzari and Giovanni Trampetti, 1948, *Boll. Soc., ital.,* biol sper., **24,** 1102-3.
19. Villano, F., and Langella, G. (Univ. Nalpes, Italy), 1944, *Boll. Soc. ital. Biol. Sper* **19,** 12-14; Mario De Vincentiis and Giacinto Auricchio (Univ. Nalpes). 1949, *Boll Soc. ital,* biol. Sper. **25,** 29-31.
20. Herbst, R. M., 1936, *J. Am. Chem. Soc.,* **58,** 2239-43.
21. Herbst, R. M., and Engel, 1934, *J. Biol. Chem.* **107,** 505.
22. Giri, K. V., Kalyankar, G. D., and Vaidyanathan, C. S., 1954, *Naturwissenschaften,* **41,** 14-15.
23. Cohn, Ergeb, 1931, *Physiol.* **33,** 781;
24. Edsall, 1936, *J. Chem. Phys.,* **4,** 1; 1937, **5,** 225.
25. Fritz Wiloth, 1955, *Makromol. Chem.,* **15,** 106 and British Patent June 15, 1955, **731,** 644.

SOME PROBLEMS IN OPERATIONAL CALCULUS*

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The present thesis is a collection of nine papers. The object of this thesis is to study some problems in Operational Calculus.

Let $\phi(p) = p\int_0^\infty e^{-px} f(x)\,dx$ then $\phi(p)/p$ is known as Laplace Transform $f(x)$ and is symbolically expressed as $\phi(p) \doteqdot f(x)$. Results in this transform have been given from time to time and it has been developed under the name of Operational Calculus.

Out of nine chapters first has been entitled 'Some Properties of Generalised Hankel Transform'. If $g(y) = \int_0^\infty f(x)\, J_v(xy)\,(xy)^{1/2}\,dx$, $g(y)$ is known as Hankel Transform of $f(x)$ of order v. Agrawal gave a generalisation of this transform by means of the integral equation,

$$f(x) = (\tfrac{1}{2})^{\lambda} {}_0\int^\infty (xy)^{\lambda+\frac{1}{2}} J_\lambda^\mu\left(\frac{x^2y^2}{4}\right) g(y)\,dy$$

$$\text{where } J_\mu^\lambda(x) = \sum_{\gamma=0}^{\infty} \frac{(-x)^\gamma}{\underline{|\gamma}\,\sqrt{1+\lambda+\mu\gamma}},\ \mu > 0.$$

In this chapter the following theorems have been proved and they are true subject to the condition that the integrals involved converge.

Theorem 1. If $f(x)$ is J_μ^λ - Transform of $g(y)$ and $g(p)$ is cosine transform of $\psi(t)$, then $f(x) = \int_0^\infty \psi(t)\,\varphi(t)\,dt$.

$$\text{where } \varphi(t) = \frac{\sqrt{2}}{x}\sum_{n=0}^{\infty} \frac{\Gamma\left(\frac{\lambda}{2}+\frac{3}{4}+n\right)\left(\frac{2t}{x}\right)^{2n}(-1)^n}{(\underline{|2n})\,\Gamma\left(1+\lambda-\frac{3\mu}{4}-n\mu-\frac{\lambda\mu}{2}\right)}\ 0<\mu<1,\ \lambda>-\tfrac{3}{2}$$

Theorem 2. If (x) is J_λ^μ - transform of $g(y)$ and $g(p)$ is sine transform of $\psi(t)$ and if $\phi(t) = \frac{(2)^{3/2}}{x^2}\sum_{n=0}^{\infty} \frac{(-1)^n\,\Gamma\left(\frac{\lambda}{2}+\frac{5}{2}+n\right)\left(\frac{2}{x}\right)^{2n}(t)^{2n+1}}{\Gamma(2n+1)\,\Gamma\left[1+\lambda-\mu\left(\frac{\lambda}{2}+\frac{5}{4}+n\right)\right]}$.

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* This is an abstract for the thesis, submitted of the Ph.D. degree of the Agra University.

then $f(x)={}_0\int^{\infty}\varphi(t)\psi(t)\,dt,\ 0<\mu<1\ ;\ \lambda>-\frac{5}{2}$.

Theorem 3. If $f(x)$ is J^{μ}_{λ} - transform of $g(y)$ and $g(p)$ is H-transform of $\psi(t)$, and if $\varphi(t)=(2)\ (x)^{-3/2}\ t^{1/2}$

$$\sum_{n=0}^{\infty}\frac{(-1)^n\,\Gamma\left(\frac{\lambda}{2}+\frac{\nu}{2}+n+\frac{3}{2}\right)\left(\frac{t}{x}\right)^{\nu+2n+1}}{\Gamma(n+\frac{3}{2})\,\Gamma(n+\nu+\frac{3}{2})\,\Gamma\left[1+\lambda-\mu\left(\frac{\lambda}{2}+\frac{\nu}{2}+n+\frac{3}{2}\right)\right]}$$

then $f(x)={}_0\int^{\infty}\psi(t)\,\phi(t)\,dt,\ 0<\mu<1,\ \lambda+\mu>-3.$

Theorem 4. If $f(x)$ and $g(x)$ are in J^{μ}_{λ} - transform, then

$${}_0\int^{\infty}x^{m-\frac{1}{2}}f(x)dx=2^{m}\frac{\Gamma\left(\frac{\lambda}{2}+\frac{m}{2}+\frac{1}{2}\right)}{\Gamma\left[1+\lambda-\frac{\mu}{2}(\lambda+m+1)\right]}\ {}_0\int^{\infty}g(x)/x^{m+\frac{1}{2}}dx$$

$0<\mu<1$ and Re $\lambda+m>-1$.

Theorem 5. If $f(x)$ is J^{μ}_{λ} -transform of $g(y)$, then

(a) $\frac{1}{s}f(x/s)$ is J^{μ}_{λ} –transform of $g(ys)$.

(b) $${}_x\int^{\infty}f(x)/x\,dx=(\tfrac{1}{2})^{\lambda}\ {}_0\int^{\infty}(xy)^{\lambda+\frac{1}{2}}\ J^{\mu}_{\lambda}\ (x^3y^2/4)\frac{1}{y}(dy)\ {}_0\int^{y}g(x)dx.$$

(c) $${}_0\int^{\infty}f(x)/x\,dx=(\tfrac{1}{2})^{\lambda}\ {}_0\int^{\infty}(xy)^{\lambda+\frac{1}{2}}J^{\mu}_{\lambda}\ (x^2y^2/4)\ \frac{1}{y}\,dy\ \int_{y}^{\infty}g(x)dx.$$

Chapter II entitled 'Some Properties of Hankel Transform' contains the following theorems, provided the integrals involved converge.

Theorem 1. If $f(x)$ is Hankel Transform of $g(y)$ of order ν, then

$${}_0\int^{\infty}x^{\mu}f(x)dx=\frac{2^{\mu+\frac{1}{2}}\Gamma\left(\frac{\mu}{2}+\frac{\nu}{2}+\frac{3}{4}\right)}{\Gamma\left(\frac{\nu}{2}-\frac{\mu}{2}+\frac{1}{4}\right)}\times{}_0\int^{\infty}\frac{g(x)}{x^{\mu+1}}dx$$

$$-\text{Re }\nu-\tfrac{3}{2}<\text{Re }\mu<-1$$

Theorem 2. If $\phi(y)$ is Hankel Transform of $f(x)$ of order 2ν, then $\phi(\sqrt{y})/y^{3/4}$ is Hankel Transform of

$${}_0\int^{\infty}x^{-1/2}s^{1/2}f(s)\ J_{\nu}\left(\frac{s^2}{4x}\right)ds$$ of order ν, $y>0$, Re $\nu>-\frac{1}{2}$.

Theorem 3. If $f(x)$ is Hankel Transform of $g(y)$ of order ν, then

$$\int_0^c x^{\nu+\frac{1}{2}} f(x)\,dx = c^{\nu+1} \int_0^\infty g(x) x^{-1/2} J_{\nu+1}(cx)\,dx, \ \mathrm{Re}\,\nu > -1.$$

Chapter III is entitled 'Some Properties of Generalised Laplace Transform

Dr. R. S. Verma (1947) gave generalisation of the Laplace Transform in the form $\phi(p) = p \int_0^\infty (2px)^{-1/4} W_{k,m}(2px) h(x)\,dx$...or symbolically

$$\phi(p) \overset{k}{\underset{m}{=}} h(x)$$

Since $2(px)^{-\frac{1}{4}} W_{\frac{1}{4} \pm \frac{1}{4}}(2px) = e^{-px}$, the integral reduces to Laplace Transform (i) if $k = \frac{1}{4}, m = \pm\frac{1}{4}$; also if $k = 0$ and $W_{0,m}(x) = \sqrt{(x/\pi)}\, K_m(x/2)$, the general transform reduces to $\phi(p) = p/\sqrt{\pi}) \int_0^\infty (2px)^{1/4} K_m(px) h(x)\,dx$ and represented symbolically $\phi(p) \overset{0}{\underset{m}{=}} h(x)$.

Theorems in general L-transform proved in this chapter are given below :—

They are true if the integrals involved converge.

Theorem 1. If $\phi(p) \overset{k}{\underset{m}{=}} f(x)$, then if $-\frac{1}{2} < \mathrm{R}m < \frac{1}{2}$

$$\int_0^\infty \phi(p)/p^{7/4}\,dp = \frac{(\pi)^{3/2} 2^{k-1/4} (\sec m\pi)}{\Gamma\left(\frac{3}{4} - \frac{k}{2} + \frac{m}{2}\right) \Gamma\left(\frac{3}{4} - \frac{k}{2} - \frac{m}{2}\right)} \int_0^\infty f(x)/x^{1/4}\,dx$$

Theorem 2. If $\phi(p) \overset{k}{\underset{m}{=}} \psi(x)$, $\mathrm{R}(p) > 0$, $\pm m + \frac{9}{4} > 0$

and $\psi(x)$ is sine transform of $f(y)$, then $\phi(p) = \int_0^\infty f(y)\, F(y)\,dy$

where $$F(y) = \left(\frac{\sqrt{\pi}}{8p}\right) \sum_{r=0}^{\infty} \frac{(-1)^r y^{2r+1} \Gamma[m + 2r + (9/4)] \Gamma[-m + 2r + (9/4)]}{(4p)^{2r}\, r!\, \Gamma(r + (3/2)\, \Gamma[2r - k + (11/4)]}$$

$$ {}_2F_1 \left[\begin{matrix} m + 2r + \frac{9}{4}; & -m + 2r + \frac{9}{4} \\ -k + 2r + \frac{11}{4}; \frac{1}{2} & \end{matrix}\right]$$

Theorem 3. If $\phi(p) \overset{k}{\underset{m}{=}} \psi(x)$ and $\psi(x)$ is cosine-transform of $f(y)$

then $\phi(p)=\int_0^\infty f(y)\,F(y)\,dy,\ \pm m+\frac{5}{4}>0$

where $$F(y)=\sum_{r=0}^{\infty}\frac{(-1)^r y^{2r}\Gamma(m+2r+\frac{5}{4})(\Gamma 2r-m+\frac{5}{4})}{(2p)^{2r}\,(2r)\,!\,2\Gamma(2r-k+\frac{7}{4})}$$

$$\times {}_2F_1\left(m+2r+\tfrac{5}{4},-m+2r+\tfrac{5}{4};-k+2r+\tfrac{9}{4};\tfrac{1}{2}\right)$$

Theorem 4. If $\phi(p)\overset{0}{\underset{m}{=}}h(x)$ and $h(x)$ is $\overset{\mu}{\underset{\lambda}{J}}$-transform of $f(y)$ then

$$\phi(p)=\int_0^\infty f(y)\,\psi(y)\,dy,\ R(\lambda+\tfrac{7}{4}+m)>0 \text{ where}$$

$$\psi(y)=\frac{1}{\sqrt{\pi}(p)^{\lambda+\frac{1}{2}}}\sum_{r=0}^{\infty}\frac{(-1)^r y^{\lambda+2r+\frac{1}{2}}\,\Gamma\left(\frac{\lambda+2r+\frac{7}{4}-m}{2}\right)\Gamma\left(\frac{\lambda+2r+m+\frac{7}{4}}{2}\right)}{(p)^{2r}(r!)\Gamma(1+\lambda+\mu r)}$$

Theorem 5. If $\phi(p)\overset{0}{\underset{2m}{=}}h(x)$, then $\phi(\sqrt{p}).\ \pi/(p)^{3/8}\overset{0}{\underset{m}{=}}f(x)$

$$=x^{-1/4}\int_0^\infty s^{1/4}h(s)\,K_m(s/^2 4x)\,ds$$

Theorem 6. If $g(x)$ is Hankel-transform of $f(y)$ of order ν, then

$$\int_0^\infty f(y)\sum_{r=0}^{\infty}\frac{y^{\nu+2r+\frac{1}{2}}(-1)^r\,\Gamma(\nu+2r+m+\frac{7}{4})\,\Gamma(\nu+2r-m+\frac{7}{4})}{p^{\nu+2r+\frac{1}{2}}\nu_r\,!\,\Gamma(\nu+r+1)\Gamma(\nu+2r+\frac{9}{4}-k).\,2^{2\nu+4r+3/2}}$$

$${}_2F_1(\nu+2r+m+\tfrac{7}{4},\ \nu+2r-m+\tfrac{7}{4};\ \nu+2r-k+\tfrac{9}{4};\ \tfrac{1}{2})\,dy\overset{k}{\underset{m}{=}}g(x)$$

$R(p)>0,\ R(\nu\pm m+\frac{7}{4})>0.$

Theorem 7. If $\phi(p)\overset{k}{\underset{m}{=}}h(x)$; then (a) $\phi(s/p)\overset{k}{\underset{m}{=}}h(xp^2/s)$

(b) $$p\int_{1/p}^{\infty}\phi(p)/p^2dp\overset{k}{\underset{m}{=}}1/x\int_0^{xp^2}h(x)dx.$$

The following pairs in Generalised Laplace Transform have been obtained in the same chapter.

(1) $$p\int_0^\infty (2px)^{-1/4}\,W_{k,m}(2px)\,J_n(x)\cos x\,dx$$

$$=\frac{1}{2\sqrt{\pi}}\sum_{r=0}^{\infty}\frac{(-1)^r\Gamma(n+2r+m+\frac{5}{4})\Gamma(n+2r-m+\frac{5}{4})\Gamma(n+2r+\frac{1}{2})}{p^{n+2r}2r\,!\,\Gamma(n+2r-k+\frac{7}{4})\Gamma(2n+r+1)}$$

${}_2F_1(n+2r+m+5/4;\ \ n+2r-m+5/4;\ \ n+2r-k+7/4;\tfrac{1}{2})$ $R(p)>0$, $R(n\pm m+5/4)>0$

$$(2)\ p\int_0^\infty (2px)^{-1/4} W_{k,m}(2px)\, J_n(x) \sin x\ dx$$

$$=\tfrac{1}{2}\sum_{r=0}^{\infty} \frac{(-1)^r F(n+2r+\frac{3}{2}) \Gamma(n+2r+m+\frac{9}{4})\, \Gamma(n+2r+\frac{9}{4}-m)}{\sqrt{\pi}(2r+1)!\, F(2n+2r+2)\, p^{2r+n+1} \Gamma(n+2r+\frac{11}{4}-k)}$$

${}_2F_1\ (n+2r+m+9/4,\ n+2r-m+9/4,\ n+2r-k+11/4,\ \tfrac{1}{2})$ provided $R(p) > 0$ and $R(n \pm m+9/4) > 0$

$$(3)\ p\int_0^\infty (2px)^{-1/4} W_{k,m}\ (2px)\ P_{2n}(x)\ dx$$

$$= \frac{(-1)^n (2n)\ !}{2^{2n}(n\ !)^2} \sum_{r=0}^{n} \frac{(-n)_r (n+\frac{1}{2})_r \Gamma(m+2r+\frac{5}{4}) \Gamma(2r-m+\frac{5}{4})}{(\frac{1}{2})_r\ r\ !\ \cdot 2^{2r+1} p^{2r} \Gamma(2r-k+\frac{7}{4})}$$

$${}_2F_1\ (2r+m+\tfrac{5}{4},\ 2r-m+\tfrac{5}{4},\ 2r-k+\tfrac{7}{4},\ \tfrac{1}{2})$$

$R(p) > 0$, (Re $\pm m+\frac{4}{5}) > 0$

$$(4)\ p\int_0^\infty (2px)^{-1/4} W_{k,m}\ (2px)\ P_{2n+1}(x) dx$$

$$\frac{(-1)^n (2n+1)\ !}{2^{2n}(n\ !)^2} \sum_{r=0}^{n} \frac{(-n)_r (n+\frac{3}{2})_r \Gamma(2r+m+\frac{9}{4}) F(2r-m+\frac{9}{4})}{(\frac{3}{2})_r (r\ !) 2^{2r+2} p^{2r+1} \Gamma(2r-k+\frac{11}{4})}$$

$${}_2F_1(2r+m+\tfrac{9}{4},\ 2r-m+\tfrac{9}{4};\ 2r-k+\tfrac{11}{4};\ \tfrac{1}{2})$$

$R(p) > 0$, $R(\pm m+\frac{9}{4})$ 0.

$$(5)\ p\int_0^\infty (2p\ x)^{-1/4} W_{k,\ m}(2px)\ .\frac{x^{\lambda+n}}{2^\lambda} J_\lambda^\mu \left(\frac{x^2}{4}\right) dx$$

$$= \sum_{r=0}^{\infty} \frac{F\ (\lambda+n+2r+m+\frac{5}{4})\ \Gamma\ (\lambda+n+2r-m+\frac{5}{4})}{2^{\lambda+2r}\ \ 2^{\lambda+n+2r+1}\ r\ !\Gamma(1+\lambda+\mu r)\ .\ p^{\lambda+n+2r}\ \Gamma(\lambda+n+2r-k+\frac{7}{4})}$$

$${}_2F_1\ (n+\lambda+2r+m+\tfrac{5}{4},\ \lambda+n+2r-m+\tfrac{5}{4};\ \lambda+n+2r-k+\tfrac{7}{4};\ \tfrac{1}{2})$$

$R\ (p) > 0$, $R(n+\lambda \pm m+\frac{5}{4}) > 0$.

In Chapter IV the following results is Y-transform have been obtained.

If $g\ (y) = \int_0^\infty f(x)\ Y_v\ (xy)\ (xy)^{1/2}\, dx$ then $g\ (y)$ is called Y-transform of $f\ (x)$ where $Y_v\ (z) = \text{cosec}\ v\pi\ [\,J_v\ (z)\ \cos\ v\pi - J_{-v}\ (z)]$

If $f\ (x) = e^{-x^2/8p^2} I_{v-1/2}\left(\dfrac{x}{8p^2}\right)$

$$g\ (y) = -\frac{y}{\pi y^{3/2}} \frac{\Gamma(v+1)}{\Gamma(v+\frac{1}{2})} \frac{1}{(8y)^v\, p^{2v+2}}\, {}_3F_2\left(1,\ \frac{v+1}{2}\ ,\ \frac{v+2}{2};\right.$$

$$\left.\tfrac{3}{2},\ v+\tfrac{1}{2};\ -\frac{1}{16\, y^2\, p^2}\right)$$

$$| \arg p | < \pi/4, \ \mathrm{Re}\ (\nu) > -1, \ y > 0.$$

(2) $$f\ (x) = x^{\nu - \frac{1}{2}} e^{-x/4p^2} \cdot {}_1F_1(\nu - \mu + 1 ; 2\nu + 1 ; x/4p^2)$$

$$g\ (y) = \frac{-y^{\nu - 3/2}\, \Gamma(2\nu + 1)(\mu + \nu)}{\sqrt{\pi}\ .\ p^2\, \Gamma(\nu + \frac{3}{2})\ .\ 2^{\nu + 2}}\, {}_3F_2\left(1, \frac{\mu + \nu + 1}{2} \cdot \frac{\mu + \nu + 2}{2} ; \frac{3}{2}, \nu + \frac{3}{2} ; -\frac{1}{16 y^2 p^4}\right)$$

$$y > 0, \ | \arg p | < \pi/4, \ \mathrm{R}(\mu + \nu) > -1.$$

(3) $$f\ (x) = x^{\sigma - m} \ (1 - x^2/4n^2)^{-m/2}\ \mathrm{P}_n^m(1 - x^2/2n^2)$$

$$g\ (y) = (1/2n)^m \frac{\Pi(n+m)(2n)^{\sigma+1}\Gamma(m+1)}{\sqrt{2\Pi m}\ \Pi(n-m)\ \Gamma(m+n+1)\ \Gamma(m-n)}$$

$$G^{41}_{35}\left(-n^2y^2 \,\middle|\, \begin{matrix} 1-p, m+1-p, l \\ h, k, m-n-p, m+n+1-p, 1 \end{matrix}\right)$$

where $h = \frac{1}{4} + \frac{\nu}{2}$, $k = \frac{1}{4} - \frac{\nu}{2}$, $l = -\frac{1}{4} - \frac{\nu}{2}$, $p = \frac{1}{2} + \frac{\sigma}{2}$ and

provided

$\mathrm{Re}\ \sigma < 2\ \mathrm{Re}\ (m+n+1)$, $\mathrm{Re}\ \sigma > | \mathrm{Re}\ \nu | -3/2$, $\mathrm{Re}\ 1/2n > 0$, $\mathrm{Re}\ \sigma < 2\ \mathrm{Re}\ (m-n)$.

In Chapter V and VI the following relations between Ultra-spherical Polynominals and other allied function have been obtained. For all of them $\lambda > -\frac{1}{2}$ and n is an integer.

1.0. $$\mathrm{I}_1 = \int_0^1 \mathrm{P}_n^{\lambda}\ (1 - 2y^2)(1 - y^2)^{\lambda - \frac{1}{2}} y^{\lambda} \cos\ (yz)\ \mathrm{J}_{\lambda}\ (yz)\ dy$$

$$= \frac{\Gamma(n+2\lambda)\sqrt{\pi}\ \Gamma(\lambda + 2n + \frac{1}{2})\ \Gamma(n + \lambda + \frac{1}{2})}{2^{\lambda}\ n\ !\ \Gamma(\lambda)F(n+\frac{1}{2})[\Gamma(2n+1+2\lambda)]^2}$$

$${}_2F_3\left(\frac{\lambda}{2} + n + \frac{1}{4}\ ,\ \frac{\lambda}{2} + n + \frac{3}{4} ; 2n + 2\lambda + 1 ;\ n + \frac{1}{2}, n + \lambda + 1 ;\ -z^2\right)$$

2.0. $$\mathrm{I}_2 = \int_0^1 \mathrm{P}^{\lambda}_{n}\ (1 - 2y^2)(1 - y)^{\lambda - \frac{1}{2}} \sin\ (yz)\ \mathrm{J}_{\lambda}\ (yz)\ dy$$

$$= \frac{F(n+2\lambda)\sqrt{\pi}\ \Gamma(2n + \lambda + \frac{3}{2})\ \Gamma(n + \lambda + \frac{1}{2}) z^{\lambda + 2n + 1}}{2^n\ !\ \Gamma(\lambda)\Gamma(n+\frac{3}{2})\Gamma(2n + 2\lambda + 2)\ \Gamma(2n + 2\lambda + 1)}\ {}_3F_4\ (n + \tfrac{1}{2} + \lambda)$$

$$n + \tfrac{3}{4} + \lambda/2,\ n + \lambda/2 + \tfrac{5}{4},\ n + \tfrac{3}{2},\ 2n + 2\lambda + 1,\ n + \lambda + 1,\ n + \lambda + \tfrac{3}{2} ; -z^2).$$

3.0. $$\mathrm{I}_3 = \int_0^1 \mathrm{P}^{\lambda}_{n}\ (1 - 2y^2)\ (1 - y^2)^{\lambda - \frac{1}{2}} \mathrm{J}_{\lambda + \frac{1}{2}}\ (yz)\ \mathrm{J}_{\lambda - \frac{1}{2}}\ (yz)\ dy$$

$$= \frac{\sqrt{\pi}(z/2)^{2n + 2\lambda}}{2^{\lambda}(n!)F(\lambda)\Gamma(n + \lambda + \frac{3}{2})(n + 2\lambda)}$$

$${}_2F_3\ (n + \lambda + \tfrac{1}{2},\ n + \lambda + 1 ;\ n + \lambda + \tfrac{3}{2},\ 2n + 2\lambda + 1,\ n + 2\lambda + 1 ;\ -z^2).$$

$$I_{3.1}=\int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}\,y\Big[J_{\lambda+\frac{1}{2}}(yz)\,J_{\lambda-3/2}(yz)-\Big\{J_{\lambda+\frac{1}{2}}(yz)\Big\}^2+\Big\{J_{\lambda-\frac{1}{2}}(yz)\Big\}^2-J_{\lambda-\frac{1}{2}}(yz)\,J_{\lambda+3/2}(yz)\Big]dz$$

$$=\frac{\sqrt{\pi}(z/2)^{2n+2\lambda-1}\,(2n+2\lambda)}{\Gamma(\lambda)^{2\lambda}(n!)\Gamma(n+\lambda+\frac{3}{2})(u+2\lambda)}$$

$${}_3F_4(n+\lambda+\tfrac{1}{2},\ n+\lambda+I,\ n+\lambda+1;n+\lambda+\tfrac{3}{2},\ n+2\lambda+1,\ 2n+2\lambda+1,\ n+\lambda,-z^2).$$

3.2 $$\int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}{}_2F_2(\lambda+1,\ \lambda+\mu;\ \lambda+\tfrac{3}{2},\ 2\lambda+1;\ -y^2/p^2)dy$$

$$=\frac{\sqrt{\pi}\Gamma(\lambda+\frac{1}{2})\Gamma(\lambda+\frac{3}{2})F(n+\lambda+\mu)}{2^{2n+2\lambda+1}\ (n!)\Gamma(\lambda)p^{2n}\Gamma(\lambda+\mu)(n+2\lambda)F(n+\lambda+\frac{3}{2})}$$

$${}_3F_3(n+\lambda+\tfrac{1}{2},\ n+\lambda+1,\ \ n+\lambda+\mu;\ \ n+\lambda+\tfrac{3}{2},\ n+2\lambda+1,\ 2n+2\lambda+1;\ \ -1/p^2)$$
provided $|\ \arg p\ |<\pi/4$, $R(2\lambda+2p)>0$.

4.0 $$\int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}{}_mF_p(a_1,a_2\dots,a_m;\beta_1,\beta_1,\dots,\beta_p;-y^2z^2)dy$$

$$=\frac{\sqrt{\pi}F(n+2\lambda)(a_1)_n\cdots(a_m)_nF(u+\lambda+\frac{1}{2})z^{2n}}{2^{2\lambda}n!\Gamma(\lambda)(\beta_1)_n\cdots(\beta_q)_nF(2n+2\lambda+1)}$$

$${}_{m+1}F_{p+1}\left[\begin{matrix}a_1+n,a_2+n,\dots,a_m+n,\ n+\lambda+\frac{1}{2};\\ \beta_1+n,\beta_2+n,\dots,\beta_q+n,2n+2\lambda+1;\end{matrix}-z^2\right]$$ provided $m\not>p$

5.0 $$I_5=\int_0^1 P_n^{\lambda}(1-2y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}J_\nu(yz)J_\mu(yz)dy$$

$$=\frac{\sqrt{\pi}(-)^nF(n+2\lambda)(z/2)^{\nu+\mu}\ F(\nu+\mu)/2+1]\Gamma[(\mu+\nu)/2+\lambda+\frac{1}{2}]}{2^{2\lambda}n!F(\lambda)F(\mu+1)F(\nu+1)F[(\mu+\nu)/2-n+1]F[(\mu+\nu)/2+n+2\lambda+1]}$$

$$\times{}_4F_5\left[\frac{\mu+\nu}{2}+1,\ \frac{\mu+\nu}{2}+\lambda+\tfrac{1}{2},\ \frac{\mu+\nu+1}{2},\ \frac{\mu+\nu+2}{2};\ \mu+1,\ \nu+1,\ \mu+\nu+1,\frac{\mu+\nu}{2}-n+1,\frac{\mu+\nu}{2}+n+2\lambda+1;(-2z)^2\right]$$

6.0 $$I_6=\int_0^1 P_n^{\lambda}(1-2y^2)\ (1-y^2)^{\lambda-\frac{1}{2}}y^{\lambda+\nu+\frac{1}{2}}J_{\lambda-\frac{1}{2}}(yz)J_\nu(yz)dy$$

$$=\frac{(z/2)^{\lambda+\mu-\frac{1}{2}}\ \sqrt{\pi}\Gamma(n+2\lambda)(-1)^n\Gamma(\lambda+\nu+\frac{1}{2})}{2^{2\lambda}\ n!\Gamma(\lambda)\Gamma(\lambda+\frac{1}{2})\Gamma(\nu-n+1)\Gamma(\nu+n+2\lambda+1)}$$

$$\times{}_2F_3\left[\frac{\lambda+\nu}{2}+\frac{3}{4},\frac{\lambda+\nu}{2}+\frac{1}{4};\lambda+\tfrac{1}{2},\ \nu+1-n,\ \nu+2\lambda+n+1;-z^2\right]$$

7.0. $$I_7=\int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}P_{2\mu}(yz)dy$$

$$=\frac{(-1)^{n+\mu}\Gamma(n+2\lambda)\Gamma(2\mu)\sqrt{\pi}(z)^{2n}(-\mu)_{n}(\mu+\frac{1}{2})_{n}\Gamma(n+\lambda+\frac{1}{2})}{2^{2(\lambda+\mu)}n!.\Gamma(\lambda)(\mu!)^{2}(\frac{1}{2})_{n}\Gamma(2n+2\lambda+1)}$$

$$\times{}_{3}F_{2}(-\mu+n,\ \mu+\tfrac{1}{2}+n,\ n+\lambda+\tfrac{1}{2};\ n+\tfrac{1}{2},\ 2n+2\lambda+1;\ z^{2})$$

where μ, n are integers and $\mu>n$.

In Chapter VI

(1) $$\int_{0}^{1} P_{n}^{\lambda}(1-2y^{2})(1-y^{2})^{\lambda-\frac{1}{2}}y^{\lambda+\mu}K_{\lambda-\mu}(2ay)\,dy$$

$$=\frac{\pi\Gamma(n+2\lambda)(-1)^{\mu}}{2^{2\lambda}n!\,\Gamma(\lambda)a^{\lambda-\mu}}\ \frac{d^{\mu}}{d(a^{2})^{\mu}}I_{\lambda+n}(a)K_{n+\lambda}(a)$$

where a is a real positive number and $R(\lambda) < 2(\mu)+\frac{3}{2}$, μ is an interger

(2) $$\int_{0}^{1} P_{\lambda}^{n}(1-2y^{2})\ (1-y^{2})^{\lambda-\frac{1}{2}}y^{2\lambda}/(a^{2}+4y^{2})^{\lambda+\mu+1}\,dy$$

$$=-\frac{\sqrt{\pi}\Gamma(n+2\lambda)\cos(\lambda.\pi)(a^{4}+4a^{2})^{-\mu/2-\frac{1}{4}}}{(n!)\Gamma(\lambda)\Gamma(\lambda+\mu+1)2^{4\lambda}\sin[(\lambda+\mu)\pi]}Q_{n+\lambda-\frac{1}{2}}^{\mu+1}\left(\frac{a^{2}+2}{2}\right)$$

$a>0$, $R(\lambda+1)>R(\mu)$.

(3) $$\int_{0}^{1} P_{\mu}^{\lambda}(1-2y^{2})\ (1-y^{2})^{\lambda-\frac{1}{2}}y^{\lambda+\frac{1}{2}}K_{\lambda-\frac{1}{2}}(ay)\,dy$$

$$=\frac{(\pi)^{3/2}\Gamma(n+2\lambda)}{(n!)\,\Gamma(\lambda)2^{\lambda-\frac{1}{2}}}\ \frac{J_{2n+2\lambda}(a)-J_{2n+2\lambda}(a)}{a^{\lambda+\frac{1}{2}}\sin(2\lambda)\pi}$$

$\lambda>2$, $R(a)>0$.

(4) $$\int_{0}^{1}\frac{P_{n}^{\lambda}(1-2y^{2})(1-y^{2})^{\lambda-\frac{1}{2}}y^{2\lambda}}{(y^{2}+a^{2})^{\lambda}}dy$$

$$=\frac{\pi\,\Gamma(n+2\lambda)[\sqrt{(a^{2}+1)}+a]^{2n+2\lambda}}{[\Gamma(\lambda)]^{2}\,n!\,2^{2\lambda-1}\,(2n+2\lambda)}$$

(5) $$\int_{0}^{1}\frac{P_{n}^{\lambda}(1-2y^{2})\ y^{2\lambda}(1-y^{2})^{\lambda-\frac{1}{2}}}{(a^{2}+y^{2})^{\lambda+1}}dy$$

$$=\pi\frac{\Gamma(n+2\lambda)[\sqrt{(a^{2}+1)}-a]^{2n+2\lambda}}{a.n!\,\Gamma(\lambda)2^{2\lambda-2}\sqrt{(a^{2}+1)}\Gamma(1+\lambda)}$$

$$(6)\quad \int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}e^{-y^2/4p^2}$$

$$\times {}_1F_1\left(\frac{\lambda-\mu}{2}+\tfrac{3}{4},\ \lambda+\tfrac{1}{2};\ y^2/4p^2\right)dy$$

$$=\frac{\sqrt{\pi}\,\Gamma(n+2\lambda)\,\Gamma(\lambda+\frac{1}{2})\,\Gamma(n+\frac{\lambda}{2}+\frac{\mu}{2}-\frac{1}{4})\,e^{-1/4p^2}}{n!\,\Gamma(\lambda)\,\Gamma(2n+2\lambda+1)p^{2n}\,2^{2n+2\lambda}\,\Gamma\left(\frac{\lambda+\mu}{2}-\frac{1}{4}\right)}$$

$$\times {}_1F_1\left(n+\frac{3\lambda}{2}-\frac{\mu}{3}+\tfrac{5}{4};\ 2n+2\lambda+1,\ \frac{1}{4p^2}\right)$$

$$(7)\quad \int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda}\times {}_2F_1\left(\frac{\mu+\nu}{2},\frac{\lambda-\mu}{2};\ \lambda+\tfrac{1}{2},-y^2/a^2\right)dy$$

$$=\frac{\sqrt{\pi}\,\Gamma(n+2\lambda)\Gamma[n+(\lambda+\mu)/2]\Gamma[n+(\lambda-\mu)/2]\Gamma(\lambda+\frac{1}{2})}{n\,!\,2^{2\lambda}\Gamma\,(\lambda)\,a^{2n}\Gamma(\lambda+\mu)/2\Gamma(\lambda-\mu)/2\Gamma(2n+2\lambda+1)}$$

$$\times {}_2F_1\left(n+\frac{\lambda+\mu}{2},\ n+\frac{\lambda-\mu}{2};\ 2n+2\lambda+1\ ;\ -1/a^2\right)$$

$$R\,(a)>0,\ R\,\lambda)>R(\mu)$$

$$(8)\quad \int_0^1 \frac{P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}\,y^{2\lambda}\,[\sqrt{(p^2+y^2)}-p]^m}{\sqrt{(p^2+y^2)}}\,dy$$

$$=\frac{\sqrt{\pi}(-1)^n\,\Gamma(n+2\lambda)\Gamma(m+\lambda+\frac{1}{2})\,\Gamma(m+1)}{2^{2\lambda+m}n\,!\,\Gamma\,(m-n+1)\Gamma(m+n+1+2\lambda)p^{m+1}}$$

$$\times {}_3F_2\left(m+\lambda+\tfrac{1}{2},\ \frac{m+1}{2},\ \frac{m+2}{2}\ ;\ m-n+1,\ m+n+1+2\lambda;-1/p^2\right)$$

$$(9)\quad \int_0^1 P_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{\lambda}\,J_{\lambda}\,(2\sqrt{yz})I_{\lambda}\,(2\sqrt{yz})\,dy$$

$$=\frac{\sqrt{\pi}\Gamma(n+2\lambda)\Gamma(n+\lambda+\frac{1}{2}).z^{\lambda+2n}}{2^{2\lambda}(n\,!)\Gamma(2n+2\lambda+1)\Gamma(n+\lambda+1)\Gamma(2n+\lambda+1)\ \Gamma\lambda}$$

$${}_1F_4\,(n+\lambda+\tfrac{1}{2};n+\lambda+1,\ n+\lambda+\tfrac{1}{2},\ n+1+\lambda/2,\ 2n+2\lambda+1\,;-z^2/4)$$

$$(10)\quad 1=\int_0^1 p_n^{\lambda}(1-2y^2)(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda+\nu-\frac{1}{2}}M_{0,\nu}(2yz)\,dy$$

$$=\frac{\Gamma(\nu+1)\ \Gamma(\lambda+\nu+\frac{1}{2})\sqrt{\pi}.\,z^{\nu+1/2}\ \Gamma(n+2\lambda)(-1)^n}{2^{2\lambda-\nu-\frac{1}{2}}\Gamma(\lambda).n!\,\Gamma(\nu-n+1)\Gamma(\nu+n+2\lambda+1)}$$

$$\times {}_1F_2(\nu+\lambda+\tfrac{1}{2}\ ;\ \nu-n+1,\ \nu+n+2\lambda+1;\ z^2/4)$$

(11) $$\int_0^1 \mathrm{P}_n^{\lambda}(1-2y^2)\,(1-y^2)^{\lambda-\frac{1}{2}}y^{2\lambda-1}\,\mathrm{Erf}\,(yz)\,dy$$

$$=\frac{(1-1)^n\Gamma(n+2\lambda)(z)^{2n+1}\;\Gamma(n+\frac{1}{2})\Gamma(n+\lambda+\frac{1}{2})}{2^{2\lambda}n\,!\,\Gamma(\lambda)\Gamma(n+\frac{3}{2})\Gamma(2n+2\lambda+1)}\,{}_2F_2\,(n+\tfrac{1}{2},n+\lambda+\tfrac{1}{2};n+\tfrac{3}{2},\;2n+2\lambda+1;-z^2)$$

(12) $$\int_0^1 \mathrm{P}_n^{\lambda}(1-2y^2)\,(1-y^2)^{\lambda-\frac{1}{2}}y^{2(\lambda+1)}\Big/(a^2+y^2)^{\lambda+1}dy$$

$$=\frac{n\Gamma(n+2\lambda)}{\Gamma(\lambda+1)\;2^{2\lambda+1}n\,!\,.(n+\lambda)\Gamma(\lambda)}$$

$$\times\left[\frac{(n+2\lambda)\{\sqrt{(a^2+1)}-a)^{2n+2\lambda+1}}{\sqrt{(a^2+1)}}-\frac{n\{(a^2+1)-a\}^{2n+2\lambda-1}}{\sqrt{(a^2+1)}}\right]$$

In Chapter VII following results have been obtained. If $g\,(y)$ is Hankel Transform of $f\,(x)$ of order ν, then

(1) If $f(x)=x^{\nu+\frac{1}{2}}\Big/\left[\frac{4p+x^2}{4}+\sqrt{\left(\frac{2p^2+x^2p}{2}\right)}\right]^{\nu/2}$

$g(y)=2^{\nu}\;.\;\nu\;.\,y^{3/2}e^{-y\sqrt{(2p)}}$, R $(\nu)>0,\ y>0$

(2) If $f\,(x)=x^{\nu+\frac{1}{2}}\Big/\sqrt{\left(\frac{2p+x^2}{2}\right)}\left[\left(\frac{4p+x^2}{2}\right)+\sqrt{\left(\frac{2p^2+x^2p}{2}\right)}\right]^{\nu/2}$

$g(y)=2^{\nu+\frac{1}{2}}y^{-\frac{1}{2}}\;.e^{-y\sqrt{2p}}$; Re $\nu>-1, y>0.$

(3) $f(x)=x^{\mu+1}\mathrm{K}_{\mu-\nu+\frac{1}{2}}(px)$

$g(\nu)=y^{\nu+\frac{1}{2}}2^{\mu+\frac{1}{2}}\Gamma(\mu+\frac{3}{3})\,p^{\mu-\nu+\frac{1}{2}}\;(y^2+p^2)^{\mu+3/2}$,
$-1<$Re $(\mu)<2$R $(\nu)+\frac{1}{2}$; R$(\nu)>0, y>p$ (a real positive number)

(4) If $f(x)=x^{2\nu-\mu+\frac{1}{2}}\mathrm{K}_{\nu-\mu}(px)$

$$g(y)=\frac{2^{2\nu-\mu}\;y^{\nu+\frac{1}{2}}p^{\nu-\mu}\Gamma(2\nu-\mu+1)}{(p^2+y^2)^{2\nu-\mu+1}};$$

R $(\mu)<$Re$(\nu)<2$R$(\mu)+3/2$; p is a real positive number ; $y>0$

(5) If $f\,(x)=x^{\nu+\frac{1}{2}}(p^2+x^2)^{-(\mu+3/2)}$

$g(y)=p^{\,\nu-\mu-\frac{1}{2}}\;2^{-(\mu+\frac{1}{2})}\,y^{\mu+1}\mathrm{K}_{\mu-\nu+\frac{1}{2}}\;(py)/\Gamma(\mu+\frac{3}{2})$

$-\frac{1}{2}<\mathrm{Re}\, v<0;\ y>0\ ;\ y>p$ (a real positive quality),

$$-1<\mathrm{Re}\,\mu<2\mathrm{R}\nu+\tfrac{1}{2}.$$

(6) $f(x)=x^{-\nu+1/2}\,(x^2+\beta^2)^{-1}\,(x^2+p^2)^{-1/2}\,[\sqrt{(p^2+x^2)}-p]^{\mu}$

$$g(y)=y^{1/2}\quad \beta^{\mu-\nu-1}\ \mathrm{I}_{\nu}(y\beta).\frac{\pi.\sinh\,(\mu\cosh^{-1}p/\beta)}{\sin\mu\pi\sinh\,(\cosh^{-1}p/\beta)}$$

$\mathrm{Re}(\beta)>0, -1<\mathrm{R}(\mu)<1,\ \mathrm{R}\nu+1>\mathrm{R}(\mu)$ and $\mathrm{R}(p/\beta)>-,\ y>0$

(7) If $f(x)=e^{-x^2/8p^2}\ \mathrm{I}_{\nu-\frac{1}{2}}(x/8p^2)$

$$g(y)=(2p/\sqrt{\pi})\,y^{-1/2}\quad[\sqrt{(16p^4y^2+1)}-4p^2y)]^{\nu-1}/\sqrt{(16p^2y^2+1)}$$

$$|\arg p|\ <\pi/4,\ \ |y|>\tfrac{1}{4}p^2,\ \mathrm{R}\nu>-\tfrac{1}{2}.$$

(8) $f(x)=x^{\nu-1/2}\,e^{-x/4p^2}\,{}_1\mathrm{F}_1(\nu;\,2\nu+1\ :\ x/4p^2)$

$$g(y)=\frac{2^{2\nu+2}\ p^{2\nu+2}\ \Gamma(2\nu+1)\ y^{1/2}\ [\sqrt{(16p^4y^2+1)}-4p^2y]^{\nu}}{(\nu+1)\sqrt{(16p^4y^2+1)}}$$

$$|\arg\ p|<\frac{\pi}{4}\ |y|\ \frac{1}{4p^2},\ \mathrm{Re}\ \nu>-\tfrac{1}{2}.$$

(9) $f(x)=x^{\nu-\frac{1}{2}}e^{-x(1+\beta p^2)/p^2}\ {}_1\mathrm{F}_1\,(\nu,\,2\nu+1\ ;\ x/p^2)$

$$g(y)=\frac{\Gamma(2\nu+1)}{\Gamma(\nu+1)}\ p^{2\nu+2}(y^2+\beta^2)^{\frac{1}{2}}\ y^{1/2-\nu}$$

$$\times\left(\frac{\{(\beta+\beta^2p^2+p^2y^2)^2+y^2\}^{1/2}-(\beta+p^2\beta^2+p^2y^2)}{\sqrt{[(\beta+\beta^2p^2+p^2y^2)^2+y^2]}}\right)^{\nu}$$

$$|\arg p|<\pi/4,\ \mathrm{Re}\ \nu>-\tfrac{1}{2},\ \beta>0$$

$$(10)\,f(x)=\frac{(\beta^2+x^2)^{1/2.}\ x^{1/2-\nu}\ [\{\beta+\beta^2p^2+p^2x^2)^2+x^2\}^{1/2}\ -(\beta+\beta^2p^2+p^2x^2)]^{\nu}}{\sqrt{[(\beta+\beta^2p^2+p^2x^2)^2+x^2]}}$$

$$g(y)=\frac{\Gamma\nu+1}{\Gamma 2\nu+1}\left(\frac{1}{p^{2\nu+2}}\right)\ y^{\nu-\frac{1}{2}}\ e^{-y(1+\beta p^2)/p^2}\ {}_1\mathrm{F}_1\left(\nu\ ;\ 2\nu+1\ ;\frac{y}{p^2}\right)$$

$$\beta>0,\ \mathrm{Re}\ \nu>-\tfrac{1}{2}$$

In chapter VIII, the following theorems in operational calculus have been proved.

If $p\phi(p)\doteq f$ (t) then,

(1) $p(\Gamma\mu)^{-1}\int_{p}^{\infty}\varphi\,(t)(t-p)^{\mu-1}dt\doteq t^{-\mu}f\,(t)$

(2) $a^{\mu+\frac{1}{2}}p.\,\varphi\left(p\pm\frac{a}{2}\right)\doteq t^{-\frac{1}{2}-\mu}\mathrm{M}_{+(\mu+\frac{1}{2}),\,\mu}{}^{(at)}f\,t$

(3) $$\frac{p}{2}\int_0^{\infty}\phi(t)\,Erfc\left(\frac{p}{2t^{1/2}}\right)dt \doteqdot \frac{1}{t}f(t^2)$$

(4) $$p\int_0^{\infty}\phi(t)\,[J_\nu(\sqrt{2pt})]^2\,dt \doteqdot \frac{1}{t}f(t^{-1})\,I_\nu(pt)$$

$$(\nu > -\tfrac{1}{2})$$

(5) $$p\int_0^{\infty}\frac{\varphi(t)\cos(2\sqrt{pt})}{\sqrt{\pi t}}\,dt \doteqdot t^{-3/2}f\left(\frac{1}{t}\right)$$

(6) (a) $$\int_0^{\infty}e^{-pt}\cos(at)\,f(t) = \text{real part of } \varphi(p+ia)$$

(b) $$\int_0^{\infty}e^{-pt}\sin(at)\,f(t) = -\text{coef. of } t \text{ in } \varphi(p+ia)$$

If $g(y)$ is Hankel Transform $f(x)$ of order ν, then

(7) $$\frac{1}{2^\nu p^\nu}\int^{\infty}g(y)\,e^{\frac{-y^2}{4p}}\cdot y^{\nu+\frac{1}{2}}\,dy \doteqdot f(\sqrt{t})\,t^{\frac{\nu}{2}-\frac{1}{4}},\quad \nu > -1$$

(8) $$\sqrt{p\pi}\int_0^{\infty}g(y)\,e^{\frac{-y^2}{8p}}\,y^{\frac{1}{2}}\,I_{\nu/2}\left(\frac{y^2}{8p}\right)dy$$

$$\doteqdot t^{-3/4}f(\sqrt{t})$$

(9) $$2p\int_0^{\infty}g(y)\,y^{1/2}J_\nu(\sqrt{2py})\,K_\nu(\sqrt{2py})\,dy$$

$$\doteqdot f\left(\frac{1}{t}\right)t^{-1/2},\quad \nu > -1$$

If $g(y)$ is Fourier Cosine Transform of $f(x)$ then

(10) $$2\sqrt{\left(\frac{\pi}{p}\right)}\int_0^{\infty}g(y)\,e^{\frac{-y^2}{4p}} \doteqdot t^{-1/2}f(\sqrt{t})$$

(11) $$\frac{p^2}{2\sqrt{2\pi}}\int_0^{\infty}y^{-3/2}e^{-p^2/2y}g(y)\,dy$$

$$\doteqdot t.\cos(pt).\,f(t^2)$$

The last Chapter contains the following results in generalised k-function of Bateman.

If $$k_n^l(x) = \frac{2}{\pi}\int_0^{\pi/2}2l\cos^l\theta\cos(x\tan\alpha - n\theta)\,d\theta.$$

$l > -1$ (Chakrabarty 1952)

(1) $k_n^{1+r}(x)=k_{n+1}^{r}(x)+k_{n-1}^{r}(x)$

(2) $k_n^{1+r}(x)=k_{n+l}^{r-l+1}(x)+{}^{l}c_1\,k_{n+l-2}^{r-l+1}(x)\ \ldots+k_{n-l}^{r-l+1}(x)$

(3) $$\frac{2}{\pi}\tan\alpha\int_0^{\pi/2}\sin(x\tan\alpha-2n\ \theta)\cos^{2l}\theta.\ 2^{2l}\,d\theta$$

$$=k_{2n}^{2l}(x)-2k_{2n-1}^{2l-1}(x)$$

(4) $k_{2n}^{2l}(x)-2k_{2n-1}^{2l-1}(x)+\frac{d}{dx}\left[k_{2n}^{2l}(x)\right]=0$

(5) $$\frac{2}{\pi}\int_0^{\pi/2}2^{2l}\cos^{2l}\theta.\ e^{x}\ .\ \tan\alpha\sin(x\tan\alpha-2n\theta)d\theta$$

$$=\tfrac{1}{2}\,k_{2n+1}^{2l+1}(x)\ \sec^2\alpha-k_{2n}^{2l}(x)$$

(6) $-\frac{d}{dx}\ k_{2n}^{2l}(x)=\tfrac{1}{2}\sec^2\alpha\ k_{2n+1}^{2l+1}(x)-k_{2n}^{2l}(x)$

(7) $\sec^2\alpha\ k_{2n+1}^{2l+1}(x)-4k_{2n}^{2l}(x)+4k_{2n-1}^{2l-1}(x)=0$

(8) $$k_{2(m-l)}^{2l}(2x)=k_{2(m-l_1)}^{2l_1}(x)\ .\ k_{-2l_2}^{2l_2}(x)$$

$$+\,k_{2(m-1-l_1)}^{2l_1}(x)\ k_{2(1-l_2)}^{2l_2}(x)$$

where $l=l_1+l_2$

FRACTIONAL INTEGRATION AND GENERALIZED HANKEL TRANSFORM

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INTRODUCTION

Agrawal, R. P. [1] gave a generalization of the well-known Hankel transform

$$(1.1) \qquad f(x)=\int_0^\infty (xy)^{\frac{1}{2}} J_\nu \; (xy) \;\; g(y)\, dy.$$

in the form

$$(1.2) \qquad f(x)=(\tfrac{1}{2})^\lambda \int_0^\infty (xy)^{\lambda+\frac{1}{2}} \; J^\mu_\lambda \, (x^2 y^2/4)^\mu \, g(y) \;\; dy.$$

where J^μ_λ (x) is the Bessel-Maitland function defined by the series

$$(1.3) \qquad J^\mu_\lambda\,(x)=\sum_0^\infty \frac{(-x)^r}{r \;\; (1+\lambda+\mu r)}, \qquad\qquad \mu>0$$

For $\mu=1$ (1.2) reduces to (1.1).

He gave an inversion formula and some theorems for this transform. [2]

Kumar, R. [3] wrote (1.2) in the form

$$(1.4) \qquad f(x)=\int_0^\infty (xy)^\nu \;\; J^\mu_\lambda \, (xy) \;\; g(y)\;\; dy$$

and gave some recurrance relations, integral representations, and other properties of (1.4).

The object of the present paper is to give some theorems connected with generalized Hankel transforms of different orders using properties of Kober's operators. [4]

We, however, write (1.2) and (1.4) in the forms

$$(1.5) \qquad f(x)=(\tfrac{1}{2})^\lambda \int_0^\infty (xy)^{\lambda+\frac{1}{2}} J^\mu_\lambda \, (\tfrac{1}{4}x^2 y^2)^\mu \, g(y) \qquad dy$$

$$\equiv H^\mu_{\lambda+\frac{1}{2},\,\lambda} \;\; g(y)$$

$$(1.6) \qquad f(x)=\int_0^\infty (xy)^\nu \quad J^\mu_\lambda \, (xy)^\mu \quad g(y) \;\; dy$$

$$=h^{\mu}_{\nu,\ \lambda}\ g\,(y).$$

DEFINITION OF OPERATORS

The operators given by Kober 4 are defined as follows

(2.1) $$I^{+}_{\eta,\,\alpha}\ f\,(x)=\Gamma^{-1}\,(\,\alpha\,)\ x^{-\eta-\alpha}\int_{0}^{x}(x-u)^{\alpha-1}u^{\eta}\,f\,(u)\quad du$$

(2.2) $$K^{-}_{\zeta,\,\alpha}\ f\,(x)=\Gamma^{-1}\,(\,\alpha\,)\,x^{\zeta}\int_{x}^{\infty}(u-x)^{\alpha-1}\ u^{-\zeta-\alpha}\ f\,(u)\ du$$

(2.3) $$I^{-}_{\eta,\,\alpha}\ f\,(x)=\Gamma^{-1}\,(\alpha)\ x^{-\eta-\alpha}\int_{x}^{\infty}(u-x)^{\alpha-1}\ u^{\eta}\,f\,(u)\quad du$$

(2.4) $$K^{+}_{\zeta,\,\alpha}\ f\,(x)=\Gamma^{-1}\,(\alpha)\ x^{\zeta}\int_{0}^{x}(x-u)^{\alpha-1}\ u^{-\zeta-\alpha}\,f\,(u)\quad du$$

where $f\,(x)\in L_p\,(0,\infty)$, $(\,1/p\,)+(\,1/q\,)=1$ if $1<p<\infty$ and $(\,1/q\,)$ or $(\,1/p\,)=0$ if p or $q=1$, $\alpha>0$ $\eta>-(\,1/q\,)$, $\zeta>-(\,1/p\,)$.

Erdelyi and Kober (4, 5, 6) used the above operators of fractional integration and differentiation to develop the theory of Hankel transform in Tricomi's form

(2.5) $$f\,(x)=\int_{0}^{\infty}J_{\nu,\ m}\ (\,2\ t^{\frac{1}{2}}\ x^{\frac{1}{2}}\,)\ \ g\ (t)\ \ dt.$$

GENERALIZED HANKEL TRANSFORMS OF DIFFERENT ORDERS

Theorem 1. If l is a positive integer, $0<\mu\leqq 1$,

$$f\ (x)=0\ (x^{\alpha}\,)\qquad (\,x\to 0\,)$$

$$=0\ (\,x^{\beta}\,)\qquad (\,x\to\infty)$$

(*a*) $F\ (x)\ =H_{\lambda+\frac{1}{2},\,\lambda}\ f$

$g\ (z)\ =I^{-}{}_{\lambda+\frac{1}{2},\ l}\ f$

$G\quad =I^{-}{}_{\lambda+\frac{1}{2},\ l}\ F$

then

$$G\quad =\mu H^{\mu}_{\lambda+\frac{1}{2}+2\mu\,l,\ \lambda+(\mu+1)\ l}\ g,$$

provided that $\lambda+\alpha+3/2>0$, $\lambda+3/2<0$, $\beta+1<0$;

(*b*) $F\quad =\mu\ H^{\mu}_{\lambda+\frac{1}{2}+2\mu\,l,\ \lambda+(\mu+1)\ \ l}\,f$

$$g\ (z)\ = \mathrm{K}^{+}_{\lambda+\frac{1}{2},\ l}\ f$$

$$\mathrm{G}\ = \mathrm{K}^{+}_{\lambda+\frac{1}{2},\ l}\ \mathrm{F}$$

then

$$\mathrm{G}\ = \mathrm{H}^{\mu}_{\lambda+\frac{1}{2},\lambda}\ \ \mathrm{g}$$

under appropriate conditions on λ, α, β.

We shall prove these theorems for $l=1$ only. The more general case follows by repeated application of this case. Proof of Theorem 1 (a) :

We have

$$\mathrm{G}\ (x) = x^{-\lambda-3/2}\int_{x}^{\infty} t^{\lambda+\frac{1}{2}}\ \mathrm{F}\ (t)\ \ dt$$

$$= x^{-\lambda-3/2}\int_{x}^{\infty} t^{\lambda+\frac{1}{2}}\, dt\ \left(\tfrac{1}{2}\right)^{\lambda}\int_{0}^{\infty} (ty)^{\lambda+\frac{1}{2}}\ \mathrm{J}^{\mu}_{\lambda}\left(\tfrac{1}{4}t^{2}y^{2}\right)^{\mu} f(y)\ dt$$

$$= \left(\tfrac{1}{2}\right)^{\lambda}\ x^{-\lambda-3/2}\int_{0}^{\infty} y^{\lambda+\frac{1}{2}} f\ (y)\ dy\int_{x}^{\infty} t^{2\lambda+1}\ \mathrm{J}^{\mu}_{\lambda}\ \left(\tfrac{1}{4}t^{2}y^{2}\right)^{\mu}\ dt \ \ldots \quad \text{(A)}$$

$$= -\left(\tfrac{1}{2}\right)^{\lambda}\ x^{-\lambda-3/2}\int_{0}^{\infty} y^{\lambda+\frac{1}{2}} f\ (y)\ \ dy \left\{\tfrac{1}{2}x^{2\lambda+2}\ \mathrm{J}^{\mu}_{\lambda+1}\left(\tfrac{1}{4}\,x^{2}y^{2}\right)^{\mu}\ \right\}$$

since

$$(d/dt)\ \ \tfrac{1}{2}\left[t^{2\,\lambda+2}\ \mathrm{J}^{\mu}_{\lambda}\ {+1}\ \left(\tfrac{1}{4}\,t^{2}y^{2}\right)^{\mu} = t^{2\lambda+1}\ \mathrm{J}^{\mu}_{\lambda}\ \left(\tfrac{1}{4}t^{2}y^{2}\right)^{\mu}.\ \right]$$

Therefore using a result of Kober (4), we have

$$\mathrm{G}\ \ (x) = \left(\tfrac{1}{2}\right)^{\lambda+1}\int_{0}^{\infty} x^{\lambda+\frac{1}{2}}\,\mathrm{J}^{\mu}_{\lambda+1}\ \left(\tfrac{1}{4}x^{2}y^{2}\right)^{\mu}\ d\left[y^{\lambda+3/2}\ \ g(y)\right].$$

But we have (Wright, 7)

$$\mathrm{J}^{\mu}_{\lambda}\ (x) = 0\ (1) \qquad (x \to 0)$$

$$= 0\left[\ x^{-\mathrm{k}\ (\lambda+\frac{1}{2})}\ \exp\left\{(\mu\,k)^{-1}(\mu\,x)^{k}\ \cos\ (\pi k)\right\}\right], \qquad k = (1+\mu)^{-1} \qquad (x \to \infty)$$

Hence we can show that the change in the order of integration in step (A) is justified under the conditions stated.

Let us now consider the integral

$$G(x,\,N)=(\tfrac12)^{\lambda+1}\,x^{\lambda+\frac12}\int_0^N J^{\mu}_{\lambda+1}\,(\tfrac14 x^2y^2)^{\mu}\,d\Big[y^{\lambda+3/2}g\,(y)\Big]$$

Integrating by parts we have

$$G(x,\,N)=(\tfrac12)^{\lambda+1}x^{\lambda+\frac12}\Big[y^{\lambda+\frac32}g(\,y\,)\,J^{\mu}_{\lambda+1}\,(\tfrac14x^2y^2)^{\mu}\Big]^{N}_{y=0}$$

$$-(\tfrac12)^{\lambda+1}\,x^{\lambda+\frac12}\int_0^N(d/dy)\Big[J^{\mu}_{\lambda+1}\,(\tfrac14x^2y^2)^{\mu}\Big]y^{\lambda+3/2}g\,(y)\,dy$$

$$\equiv G_1(x,N)+G_2(x,\,N).$$

Using the estimates of generalized Bessel-Maitland function it is easily seen that the expression inside the square brackets vanishes for $y=0$ and also

$$\lim_{N\to\infty} G_1(x,\,N)=0$$

under the conditions of the theorem.

Again we have

$$(3.3)\qquad (d/dy)\Big[J^{\mu}_{\lambda+1}\,(\tfrac14x^2y^2)^{\mu}\Big]$$

$$=(d/dy)\sum_0^{\infty}\frac{(-1)^r\ (\tfrac14x^2y^2)^r}{r!\Gamma(2+\lambda+\mu r)}$$

$$=2\mu\sum_{r=1}^{\infty}\frac{(-1)^r\ (\tfrac14x^2)\ (\mu r\,y^{2\mu r-1}}{(r-1)!\,\Gamma(2+\lambda+\mu r)},$$ (the term by term differentiation being justified by uniform convergence of the series concerned)

$$=2\mu\sum_{s=0}^{\infty}\frac{(-1)^{s+1}(\tfrac14x^2)^{\mu s+\mu}\,y^{2\mu s+2\mu-1}}{s!\,\Gamma(2+\lambda+\mu+\mu s)}$$

$$=(2\mu/y)\ (x^2y^2/4)^{\mu}\ J^{\mu}_{\lambda+\mu+1}\ (\tfrac14x^2y^2)^{\mu}$$

and hence

$$G_2(x,\,N)=\int_0^N(\tfrac12)^{\lambda+2\mu}\,(x\,y)^{\lambda+2\mu+\frac12}\,J^{\mu}_{\lambda+\mu+1}(\tfrac14x^2y^2)^{\mu}\,g(\,y\,)\,dy\,.$$

Now $G(x)=\operatorname{lime}_{N\to\infty} G_2(x,\,N)$ and our theorem is proved.

Proof of Theorem 1 (b) :

We have

$$G(x)=x^{\lambda+\frac12}\int_0^x t^{-\lambda-3/2}\,F(t)\,dt$$

$$=\mu x^{\lambda+\frac12}\int_0^x t^{-\lambda-3/2}\,dt\int_0^\infty \left(\tfrac12\right)^{\lambda+2\mu}(ty)^{\lambda+2\mu+\frac12}\times$$

$$\times J^{\mu}_{\lambda+\mu+1}\left(\tfrac14 t^2y^2\right)^{\mu} f(y)\,dy$$

$$=\mu x^{\lambda+\frac12}\left(\tfrac12\right)^{\lambda+\frac12}\int_0^\infty y^{\lambda+2\mu+\frac12} f(y)\,dy\int_0^x t^{2\mu-1}x$$

$$\times J^{\mu}_{\lambda+\mu+1}\left(\tfrac14 t^2y^2\right)^{\mu}\,dt$$

$$=-\mu\left(\tfrac12\right)^{\lambda+2} x^{\lambda+\frac12}\int_0^\infty y^{\lambda+\frac12} f(y)\, J^{\mu}_{\lambda+1}\left(\tfrac14 x^2y^2\right)^{\mu}\,dy$$

$$=-\mu\left(\tfrac12\right)^{\lambda+2\mu} x^{\lambda+\frac12}\int_0^\infty y^{\lambda+\frac12} J^{\mu}_{\lambda+1}\left(\tfrac14 x^2y^2\right)^{\mu} y^{\lambda+3/2}\, d\left[g(y)\,y^{-\frac12-\lambda}\right]$$

The rest of the proof closely follows that of Theorem 1 (a) Here instead of (3.3) we have to use

$$(d/dy)\left[y^{2\lambda+2} J^{\mu}_{\lambda+1}\left(\tfrac14 x^2y^2\right)^{\mu}\right.=2y^{2\lambda+1} J^{\mu}_{\lambda}\left(\tfrac14 x^2y^2\right)^{\mu}$$

Corollary 1. For $\mu=1$ we get the corresponding results for Hankel transform (1.1).

Corollary 2. By the same type of proof as in Theorem 1 (a) we get the following result for (1.6).

If

$$F(t)=h^{\mu}_{\frac12\lambda,\lambda}\, f\,,$$

$$g(z)=\bar{I}_{\frac12\lambda,\,l}\, f \quad\text{and}$$

$$G=\bar{I}_{\frac12\lambda,\,l}\, F$$

then $$G=\mu H^{\mu}_{\frac12\lambda+\mu l,\ \lambda+(\mu+1)l}\, g$$

under certain conditions on λ, α, l, μ and β.

A Property of Generalized Hankel Transform

In the following theorem we have applied the operators of fractional differentiation to deduce an interesting property of generalized Hankel transform given by (1.4).

The rule for fractional differentiation is

$$(d/dw)\left[w^{\mu-1}\right]=\frac{\Gamma(\mu)}{\Gamma(\mu-\nu)}\,w^{\mu-\nu-1}$$

Theorem 2. If

$$\mathrm{F}(x)=\mathrm{h}^{\mu}_{(2/\mu),\,\lambda}\,f$$

then

$$x^{l}\,\mathrm{F}(x)=\mathrm{h}^{\mu}_{(2/\mu),\,\lambda-l\mu}\,(\partial/\partial y)^{l}\,f(y)$$

Proof :

Using inversion formula for (1.4) [3] we have

$$f(y)=(1/\mu)\int_{0}^{\infty}(xy)^{(\lambda+1)/\mu-1}\,\mathrm{J}^{(1/\mu)}_{(\lambda+1/\mu-1}\,(xy)^{1/\mu}\,\mathrm{F}(x)\,dx.$$

$$=(\mathrm{I}/\mu)\int_{0}^{\infty}(xy)^{-1+(\lambda+1)/\mu}\sum_{0}^{\infty}\frac{(xy)^{r/\mu}}{r!\,\Gamma[(\lambda+1+r)/\mu]}\,\mathrm{F}(x)\,dx$$

Therefore

$$(\partial/\partial y)^{l}\,f(y)=(1/\mu)\,(\partial\;\partial y)^{l}\int_{0}^{\infty}(xy)^{-1+(\lambda+1)/\mu}\;\times$$

$$\times\sum_{0}^{\infty}\frac{(xy)^{r/\mu}}{r!\,\Gamma[(\lambda+1+r)/\mu]}\;\mathrm{F}(x)dx$$

As the change of integration and summation can be easily justified, differentiating term by term under the sign of integration we have

$$(\partial/\partial y)^{l}\,f(y)=(1/\mu)\int_{0}^{\infty}(xy)^{-1-l+(\lambda+1)/\mu}\,\mathrm{J}^{1/\mu}_{-1-l+(\lambda+1)/\mu}\,(xy)^{1/\mu}\;\times$$

$$x^{l}\,\mathrm{F}(x)\,dx.$$

Hence on inverting we get the required result.

MELLIN TRANSFORM AND GENERALIZED HANKEL TRANSFORM

We now find out a relation between Mellin transforms of $f(x)$ and $g(x)$ where $f(x)$ and $g(x)$ are connected by relatio (1.5).

Lemma :

If $f(x)$ and $g(x)$ are connected by relation (1.5) and

$$(5.1)\quad g(y)=(1/2\pi i)\int_{c+i\infty}^{c+i\infty}\phi(s)\,y^{-s}\,ds$$

where for $s=\sigma+it$, $\phi(s)=0\,(e^{-k\,|\,t\,|})$, $|\,t\,|\rightarrow\infty$, $k>0$ and σ is a value in the strip $0<c<1$

then

$$(5.2)\ g(y)=(1/2\pi i)\int_{c+i\infty}^{c+i\infty}\frac{2^{s-\frac{1}{2}}\Gamma[(\frac{1}{2}\lambda+\frac{1}{2}s+\frac{1}{4})/\mu]}{\Gamma(\frac{1}{2}\lambda-\frac{1}{2}s+\frac{3}{4})}\,x^{-s}\,\phi(1-s)\,ds$$

valid under the condition

$$[(1/\mu)\ (\tfrac{1}{2}\lambda-\tfrac{1}{2}s-\mu+\tfrac{3}{4})]>-1$$

with an additional condition

$$[\lambda-(1/\mu)\ (\lambda-s-2\mu+3/2)]>\tfrac{1}{2}$$

in case $\mu=1$.

Proof :

We have

$$f\ (x)=(\tfrac{1}{2})^{\lambda}\int_{0}^{\infty}(x\,y)^{\lambda+\frac{1}{2}}\,J_{\lambda}^{\mu}\ (\tfrac{1}{4}x^2y^2)^{\mu}\ g\ (y)\ dy$$

Substituting the value of $g\ (y)$ from (5. 1) we get

$$f\ (x)=(\tfrac{1}{2})^{\lambda}\int_{0}^{\infty}(x\,y)^{\lambda+\frac{1}{2}}\,J_{\lambda}^{\mu}\ (\tfrac{1}{4}x^2y^2)^{\mu}\ dy\ (\tfrac{1}{2}\pi i)\int_{c-i\infty}^{c+i\infty}\phi\ (s)\,y^{-s}\ ds$$

$$=(\tfrac{1}{2})^{\lambda}\ (\tfrac{1}{2}\pi\ i)\ x^{\lambda+\frac{1}{2}}\int_{c-i\infty}^{c+i\infty}\phi\ (s)\ ds\int_{0}^{\infty}y^{\lambda-s+\frac{1}{2}}\,J_{\lambda}^{\mu}\ (\tfrac{1}{4}x^2y^2)^{\mu}\ dy$$

under the conditions of the Lemma.

$$=(\tfrac{1}{2}\pi i)\int_{c-i\infty}^{c+i\infty}\frac{2^{s-\frac{1}{2}}\,\Gamma[(\frac{1}{2}\lambda+\frac{1}{2}s+\frac{1}{4})/\mu]}{\Gamma\ (\frac{1}{2}\lambda-\frac{1}{2}s+{}^{3}/_{4})}\,x^{-s}\,\phi\ (1-s)\ ds$$

using the following result due to Gupta (8)

$$\int_{0}^{\infty}s^{\nu}\ J_{\lambda}^{\mu}\ (sw)\ ds=\frac{\Gamma\ (1+x)}{\Gamma\ (1+\lambda-\mu-\mu\nu)}\,w^{-\nu-1}$$

valid for $\mu\leqq 1$ and $\nu>-1$ with an additional condition $(\lambda-2\nu)>\frac{1}{2}$ in case $\mu=1$.

This proves our Lemma.

Theorem 3. If $f_1\ (s)$ denotes the Mellin transform of $f\ (s)$ and $g_1\ (s)$ the Mellin transform of $g\ (s)$, then

$$\frac{f_1\ (s)}{g_1\ (1-s)}=\frac{2^{\,s-\frac{1}{2}}\,\Gamma\ [(\frac{1}{2}\lambda+\frac{1}{2}s+\frac{1}{4})/\mu]}{(\frac{1}{2}\lambda-\frac{1}{2}s+\frac{3}{4})}.$$

Proof :

We have from (5.2)

$$f_1\ (s)=\frac{2^{s-\frac{1}{2}}\,\Gamma[(\frac{1}{2}\lambda+\frac{1}{2}s+\frac{1}{4})/\mu]}{\mu\,\Gamma\ (\frac{1}{2}\lambda-\frac{1}{2}s+\frac{3}{4})}\,\phi\ (1-s)$$

and from (5.1)

$$g_1\ (1-s)\ =\phi\ (1-s).$$

Therefore

$$\frac{f_1(s)}{g_1(1-s)}=\frac{2^{s-\frac{1}{2}}\,\Gamma[(\frac{1}{2}\lambda+\frac{1}{2}s+\frac{1}{4})/\mu]}{\mu\,\Gamma(\frac{1}{2}\lambda-\frac{1}{2}s+\frac{3}{4})}$$

which proves our theorem.

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REFERENCES

1. Agrawal, R. P. (1950) *Annals de la Soc, Scient. de Bruxelles*, pp. 164-168.
2. Agrawal, R. P. (1951) *Bull. Cal. Math. Soc.*, **43**. pp. 153-167.
3. Kumar, R. (1954) *Ganita*. **5**, pp. 191-202.
4. Kober, H. (1940) *Quart. Jour. Math.* (*Oxford*), **11**, pp. 193-211.
5. Erdelyi, A. (and Kober, H. (1940) *Quart. Jour. Math* (*Oxford*), **11**, pp. 212-221.
6. Erdelyi, A. (1940) *Quart. Jour. Math.* (*Oxford*) **11**, pp. 293-303.
7. Wright, E. M. (1933) *Jour. Lond. Math. Soc.*, **8**, pp. 71-80.
8. Gupta, H. C. (1948) *Proc. Nat. Inst. Sc.* (*India*), **14**, pp. 131-156.

A VARIATIONAL PRINCIPLE FOR FULLY DEVELOPED LAMINAR HEAT TRANSFER IN UNIFORM CHANNELS, THE LIQUID HAVING ANISOTROPIC CHARACTER

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Introduction

Recently the technique of variational procedures has been applied to problems of heat transfer. Some of these have been applied to problems of pure conduction and others to forced convection of heat in fluid flow. Papers where these procedures have been adopted are given at the end. (See references 1, 2, 3, 4, 5, 6 and 7).

In this note a variational principle for forced convection of heat in a uniform channel has been formulated, the liquid having its conductivity matrix given by

$$\begin{bmatrix} K_{11} & 0 & 0 \\ 0 & K_{22} & K_{23} \\ 0 & K_{22} & K_{33} \end{bmatrix}. \tag{1.1}$$

The variational principle : The equation for steady and forced convection of heat in uniform channels for an incompressible fluid whose conductivity matrix is given by (1.1) is

$$cU\frac{\partial \theta}{\partial x} = K_{11}\frac{\partial^2 \theta}{\partial x^2} + K_{22}\frac{\partial^2 \theta}{\partial y^2} + (K_{23}+K_{32})\frac{\partial^2 \theta}{\partial x \partial y} + K_{33}\frac{\partial^2 \theta}{\partial z^2} + \phi, \tag{2.1}$$

c is the heat capacity per unit volume of the fluid, $U(y,z)$ the fully developed laminar velocity in the channel, and K_{22}, K_{23}, K_{32} and K_{33} are supposed constants. ϕ is the viscous dissipation function and θ the temperature at any point of the fluid. The x-axis is parallel to the generators of the tube, the tubular surface being given by

$$f(y,z) = 0, \quad x \geqslant 0. \tag{2.2}$$

The equation (2.1) represents a three dimensional phenomenon in the three variables (x, y, z). We now introduce a time like variable ζ $(x = U_0\zeta)$, where U_0 is a typical velocity of the system. Replacing U by U_0v, where v is the dimensionless velocity, equation (2.1) becomes

$$cv\frac{\partial \theta}{\partial \zeta} - K_{11}\frac{\partial^2 \theta}{\partial \zeta^2} = K_{22}\frac{\partial^2 \theta}{\partial y^2} + (K_{23}+K_{32})\frac{\partial^2 \theta}{\partial z \partial y} + K_{33}\frac{\partial^2 \theta}{\partial z^2} + \phi. \tag{2.3}$$

In order to formulate the variational principle equivalent to (2.3) we define certain quantities. If $\mathbf{j}$ and $\mathbf{k}$ are unit vectors in the directions of y and z, a vector field $\mathbf{H}$ is defined by

$$\mathbf{H} = \mathbf{j}H_2 + \mathbf{k}H_3. \tag{2.4}$$

H_2 and H_3 will be defined later. The law of conservation of energy is expressed by the relation

$$c\theta = -\nabla.\mathbf{H} \quad , \quad \nabla = \mathbf{j}\frac{\partial}{\partial y} + \mathbf{k}\frac{\partial}{\partial z}. \tag{2.5}$$

A thermal potential V is defined by

$$V = \tfrac{1}{2}\int\int_A c\theta^2 dy\, dz, \tag{2.6}$$

where A denotes a cross-section of the channel. It is obvious that the differential equation (2.3) which governs the problem is equivalent to the following two equations :

$$\left.\begin{aligned} K_{22}\frac{\partial\theta}{\partial y} + K_{23}\frac{\partial\theta}{\partial z} &= -v\frac{\partial H_2}{\partial\zeta} + \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\zeta^2} + N_2 \\ K_{32}\frac{\partial\theta}{\partial y} + K_{33}\frac{\partial\theta}{\partial z} &= -v\frac{\partial H_3}{\partial\zeta} + \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\zeta^2} + N_3 \end{aligned}\right\}, \tag{2.7}$$

where

$$\frac{\partial N_2}{\partial y} + \frac{\partial N_3}{\partial z} = \left[\frac{\partial H_2}{\partial\xi}\quad\frac{\partial v}{\partial y} + \frac{\partial H_3}{\partial\xi}\quad\frac{\partial v}{\partial z}\right] - \phi. \tag{2.8}$$

For operation on the first of (2.7) by $\partial/\partial y$ and on the second by $\partial/\partial z$ and subsequent addition leads to (2.3).

If the two matrices

$$\begin{bmatrix} K_{22} & K_{23} \\ K_{32} & K_{33} \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} \lambda_{22} & \lambda_{23} \\ \lambda_{32} & \lambda_{33} \end{bmatrix}$$

are inverse to each other, the above equations can be written as

$$\left.\begin{aligned} \frac{\partial\theta}{\partial y} &= -\Big[\lambda_{22}\Big(v\frac{\partial H_2}{\partial\xi} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\xi^2} - N_2\Big) \\ &\qquad + \lambda_{23}\Big(v\frac{\partial H_3}{\partial\zeta} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_3}{\partial\zeta^2} - N_3\Big)\Big] \\ \text{and} \\ \frac{\partial\theta}{\partial z} &= -\Big[\lambda_{32}\Big(v\frac{\partial H_2}{\partial\zeta} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\zeta^2} - N_2\Big) \\ &\qquad + \lambda_{33}\Big(v\frac{\partial H_3}{\partial\zeta} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_3}{\partial\zeta^2} - N_3\Big)\Big] \end{aligned}\right\}. \tag{2.9}$$

Definc a variational invariant δD by

$$\begin{aligned} \delta D = \int\int_A \Big[&\Big\{ \lambda_{22}\Big(v\frac{\partial H_2}{\partial\zeta} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\xi^2} - N_2\Big) \\ &+ \lambda_{23}\Big(v\frac{\partial H_3}{\partial\zeta} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\zeta^2} - N_3\Big) \Big\}\,\delta H_2 \\ &+ \Big\{ \lambda_{32}\Big(v\frac{\partial H_2}{\partial\zeta^2} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_2}{\partial\zeta^2} - N_2\Big) \\ &+ \lambda_{33}\Big(v\frac{\partial H_3}{\partial\zeta} - \frac{K_{11}}{cU_0^2}\frac{\partial^2 H_3}{\partial\zeta^2} - N_3\Big) \Big\}\,\delta H_3 \Big] dydz. \end{aligned} \tag{2.10}$$

The variational principles is now stated as

$$\delta V+\delta D=\int_C \theta \mathbf{n}.\ \delta \mathbf{H}\ ds, \tag{2.11}$$

the line integral extending over the closed curve C bounding a section of the tube. Now

$$\delta V=\int\int_A \theta\ \delta(c\theta)\ dydz=-\int\int_A \theta\ \delta(\nabla.\mathbf{H})\ dydz,$$

$$=\int\int_A \nabla\theta.\ \delta\mathbf{H}\ dydz+\int_C \theta\ \mathbf{n}.\ \delta\mathbf{H}\ ds$$

$$=\int\int_A \left(\frac{\partial\theta}{\partial y}\ \delta H_2+\frac{\partial\theta}{\partial z}\delta H_3\right)dydz+\int_C \theta\ \mathbf{n}.\ \delta\mathbf{H}\ ds. \tag{2.12}$$

Using expressions for δV and δD from (2.12) and (2.10) and substituting in (2.11) we get

$$\int\int_A\Bigg[\Bigg\{\frac{\partial\theta}{\partial y}+\lambda_{22}\left(v\frac{\partial H_2}{\partial\zeta}-\frac{K_{11}}{cU_0^2}\quad\frac{\partial^2 H_2}{\partial\zeta^2}-N_2\right)$$

$$+\lambda_{23}\left(v\frac{\partial H_3}{\partial\zeta}-\frac{K_{11}}{cU_0^2}\quad\frac{\partial^2 H_3}{\partial\zeta^2}-N_3\right)\Bigg\}\ \delta H_2$$

$$+\Bigg\{\frac{\partial\theta}{\partial z}+\lambda_{32}\left(v\frac{\partial H_2}{\partial\zeta}-\frac{K_{11}}{cU_0^2}\quad\frac{\partial^2 H_2}{\partial\zeta^2}-N_2\right)$$

$$+\lambda_{33}\left(v\frac{\partial H_3}{\partial\zeta}-\frac{K_{11}}{cU_0^2}\quad\frac{\partial^2 H_3}{\partial\zeta^2}-N_3\right)\Bigg\}\ \partial H_3\Bigg]\ dydz=0. \tag{2.13}$$

Since δH_2 and δH_3 are arbitrary variations in H_2 and H_3, the above equation will be satisfied if we equate their coefficients separately to zero. This will lead to equations (2.9) which we have seen are equivalent to (2.7) and hence to the main differential equation (2.3). Thus the variational principle stands justified.

The case of plug flow is obviously a special case when v can be taken to be unity, U_0 being the constant velocity over any section. The Lagrangian formulation of the problem can be carried out in the same manner as in Ref. 7.

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REFERENCES

1. Chambers, L. C., Quart. J. Mech. Appl. Math. 9(1956) 234.
2. Rosen, P., J. Chem. Phys. 21 (1953) 1220.
3. Biot, M. A., J. Aero. Sci. 24 (1957) 857.
4. Sparrow, E. M. & R. Siegel, Trans. Amer. Soc. Mech. Engrs. 81c, 2 (May 1959).
5. Nigam, S. D., and H. C. Agrawal, J. M. A. M., Forthcoming.
6. Agrawal, H. C., Forthcoming.
7. Gupta, S. C. Applied Scientific Research, Forthcoming.

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Editor